TRANSACTIONS

6

OF THE

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ROYAL SOCIETY OF SOUTH AFRICA.

VOL. XXII.

NOTE ON RELATIONS BETWEEN THE PRIMARY MINORS OF A 3-BY-9 ARRAY.

By Sir THOMAS MUIR, F.R.S.

1. The minor determinants in question may be conveniently denoted by the numbers of their columns in the array: thus 123 then stands for the first primary minor and 789 for the last.

Beginning then with the product of two, say 456 and 789, we know from Bézout (1779) that

$$456 \cdot 789 = 457 \cdot 689 + 458 \cdot 769 + 459 \cdot 786;$$

and therefore on multiplying by 123

$$123 \cdot 456 \cdot 789 = 457(123 \cdot 689) + 458(123 \cdot 769) + 459(123 \cdot 786);$$

whence by again using Bézout

$$\begin{aligned} 123 \cdot 456 \cdot 789 = \quad & 457(126 \cdot 389 + 128 \cdot 639 + 129 \cdot 683) \\ & + 458(127 \cdot 369 + 126 \cdot 739 + 129 \cdot 763) \\ & + 459(127 \cdot 386 + 128 \cdot 736 + 126 \cdot 783), \end{aligned}$$

—a result which may be viewed as expressing a product of three 3-line determinants as a sum of nine such products, or as giving a ternary relation between sixteen of the primary minors of a 3-by-9 array.

2. As at several stages of this procedure, and notably at every use of Bézout's theorem, optional courses are open to us, it is evident that many variants of the result obtained may be possible. For example, beginning with the product $123 \cdot 789$ and then multiplying by 456 we have

$$\begin{aligned}456(123 \cdot 789) &= 456(127 \cdot 389 + 128 \cdot 739 + 129 \cdot 783),\\ &= 127(456 \cdot 389) + 128(456 \cdot 739) + 129(456 \cdot 783),\\ &= 127(453 \cdot 689 + 436 \cdot 589 + 356 \cdot 489)\\ &\quad + 128(453 \cdot 769 + 436 \cdot 759 + 356 \cdot 749)\\ &\quad + 129(453 \cdot 786 + 436 \cdot 785 + 356 \cdot 784),\end{aligned}$$

where as before we have the product $123 \cdot 456 \cdot 789$ expressed as a sum of nine such products, but where this time we have a ternary relation connecting not sixteen but eighteen of the primary minors of the array.*

It has to be noted also that only three minors, namely, 127, 128, 129, are common to the two expansions.

3. The reason for sixteen minors being involved in the one case and eighteen in the other is not readily apparent. It would seem, however, to be in the main part due to the fact that in the one case we used 6 once and 3 thrice as our interchanging numbers, whereas in the second case we kept to the use of 3 throughout.

A more interesting related question is as to the existence of symmetry in the right-hand member of either result—symmetry, that is to say, in regard to the use of the elements of the three factors of the left-hand member.

4. There is another mode of presenting the subject—the Cayleyan mode we may not inappropriately call it—namely, by expressing the identities (1) and (2) in the form of vanishing 9-line determinants.

If the three minors 123, 456, 789 be now denoted by $|a_1 b_2 c_3|$, $|r_1 s_2 t_3|$, $|x_1 y_2 z_3|$, let us consider the determinant

$$\begin{vmatrix} a_1 & b_1 & c_1 & \cdot & \cdot & \cdot & x_1 & y_1 & z_1 \\ a_2 & b_2 & c_2 & \cdot & \cdot & \cdot & x_2 & y_2 & z_2 \\ a_3 & b_3 & c_3 & \cdot & \cdot & \cdot & x_3 & y_3 & z_3 \\ \cdot & \cdot & -c_1 & r_1 & s_1 & t_1 & \cdot & \cdot & \cdot \\ \cdot & \cdot & -c_2 & r_2 & s_2 & t_2 & \cdot & \cdot & \cdot \\ \cdot & \cdot & -c_3 & r_3 & s_3 & t_3 & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & r_1 & s_1 & t_1 & x_1 & y_1 & z_1 \\ \cdot & \cdot & \cdot & r_2 & s_2 & t_2 & x_2 & y_2 & z_2 \\ \cdot & \cdot & \cdot & r_3 & s_3 & t_3 & x_3 & y_3 & z_3 \end{vmatrix}.$$

In the first place by performing on it the operations

$$\begin{gathered}\mathrm{row}_1 + \mathrm{row}_4 - \mathrm{row}_7\\ \mathrm{row}_2 + \mathrm{row}_5 - \mathrm{row}_8\\ \mathrm{row}_3 + \mathrm{row}_6 - \mathrm{row}_9\end{gathered}$$

* This has recently been obtained in another manner by R. A. Beaver in the *American Mathematical Monthly*, xxxix, p. 276.

the first rows become

$$\begin{matrix} a_1 & b_1 & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ a_2 & b_2 & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ a_3 & b_3 & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \end{matrix}$$

and the determinant is seen to vanish.

In the second place, by Laplace's expansion-theorem it is seen to be

$$\begin{aligned} = \; & |a_1 b_2 c_3|\,|r_1 s_2 t_3|\,|x_1 y_2 z_3| \\ & - |a_1 b_2 x_3| \begin{vmatrix} c_1 & r_1 & s_1 & t_1 & \cdot & \cdot \\ c_2 & r_2 & s_2 & t_2 & \cdot & \cdot \\ c_3 & r_3 & s_3 & t_3 & \cdot & \cdot \\ \cdot & r_1 & s_1 & t_1 & y_1 & z_1 \\ \cdot & r_2 & s_2 & t_2 & y_2 & z_2 \\ \cdot & r_3 & s_3 & t_3 & y_3 & z_3 \end{vmatrix} + |a_1 b_2 y_3| \begin{vmatrix} c_1 & r_1 & s_1 & t_1 & \cdot & \cdot \\ c_2 & r_2 & s_2 & t_2 & \cdot & \cdot \\ c_3 & r_3 & s_3 & t_3 & \cdot & \cdot \\ \cdot & r_1 & s_1 & t_1 & x_1 & z_1 \\ \cdot & r_2 & s_2 & t_2 & x_2 & z_2 \\ \cdot & r_3 & s_3 & t_3 & x_3 & z_3 \end{vmatrix} - |a_1 b_2 z_3| \begin{vmatrix} c_1 & r_1 & s_1 & t_1 & \cdot & \cdot \\ c_2 & r_2 & s_2 & t_2 & \cdot & \cdot \\ c_3 & r_3 & s_3 & t_3 & \cdot & \cdot \\ \cdot & r_1 & s_1 & t_1 & x_1 & y_1 \\ \cdot & r_2 & s_2 & t_2 & x_2 & y_2 \\ \cdot & r_3 & s_3 & t_3 & x_3 & y_3 \end{vmatrix} \end{aligned}$$

$$\begin{aligned} = \; & |a_1 b_2 c_3|\,|r_1 s_2 t_3|\,|x_1 y_2 z_3| \\ & - |a_1 b_2 x_3|\,\{|c_1 r_2 s_3|\,|t_1 y_2 z_3| - |c_1 r_2 t_3|\,|s_1 y_2 z_3| + |c_1 s_2 t_3|\,|r_1 y_2 z_3|\} \\ & + |a_1 b_2 y_3|\,\{|c_1 r_2 s_3|\,|t_1 x_2 z_3| - |c_1 r_2 t_3|\,|s_1 x_2 z_3| + |c_1 s_2 t_3|\,|r_1 x_2 z_3|\} \\ & - |a_1 b_2 z_3|\,\{|c_1 r_2 s_3|\,|t_1 x_2 y_3| - |c_1 r_2 t_3|\,|s_1 x_2 y_3| + |c_1 s_2 t_3|\,|r_1 x_2 y_3|\}. \end{aligned}$$

Consequently we have, if we change to the other notation,

$$\begin{aligned} 0 = 123 \cdot 456 \cdot 789 \; & - 127(345 \cdot 689 - 346 \cdot 589 + 356 \cdot 489) \\ & - 128(345 \cdot 679 - 346 \cdot 579 + 356 \cdot 479) \\ & - 129(345 \cdot 678 - 346 \cdot 578 + 356 \cdot 478); \end{aligned}$$

and this is essentially identical with the result of § 2.

5. Variants of the 9-line determinant may manifestly be got with ease. We have only to make, for example, the elements of $|r_1 s_2 t_3|$ change places with the corresponding elements of $|x_1 y_2 z_3|$. We are not, however, any nearer symmetry in our expression for $|a_1 b_2 c_3| \cdot |r_1 s_2 t_3| \cdot |x_1 y_2 z_3|$ than before: indeed it is if anything more clearly awanting.

RONDEBOSCH, S. AFRICA,
25th August 1932.

NOTE ON AN OVERLOOKED ALTERNANT.

By Sir THOMAS MUIR, F.R.S.

1. The alternant in question with the value assigned to it is

$$\begin{vmatrix} 1 & (a-n) & (a-n)^2 & \ldots & (a-n)^n \\ 1 & (a-n+1) & (a-n+1)^2 & \ldots & (a-n+1)^n \\ 1 & (a-n+2) & (a-n+1)^2 & \ldots & (a-n+1)^n \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ 1 & a & a^2 & \ldots & a^n \end{vmatrix} = 1!\,2!\,\ldots\,n!$$

It was first made known in the year 1896 by V. de Strékalof on p. 200 of the *Nouv. Ann. de Math.*, 3rd ser., vol. xv. A glance at the determinant form tells us that its order is the $(n+1)^{\text{th}}$ and that further this n occurs overtly in the specification of the elements: similarly a glance at the evaluation shows us that the determinant is in reality independent of a.

2. Diminishing each column of the determinant, D_{n+1} say, by $a-n$ times the immediately preceding column we readily obtain

$$D_{n+1} = n!\,D_n,$$

whence of course follows the so-called evaluation.

3. By part of what has been said in § 1 it is suggested that there might be interest in considering the determinant which differs from D_n in not having the n that is subtracted from a in the elements the same as the n of the order-number. If then we write ν for the former and retain the latter unchanged, ν being not less than n, what we obtain is

$$\begin{vmatrix} 1 & a-\nu & (a-\nu)^2 & \ldots & (a-\nu)^n \\ 1 & a-\nu+1 & (a-\nu+1)^2 & \ldots & (a-\nu+1)^n \\ 1 & a-\nu+2 & (a-\nu+2)^2 & \ldots & (a-\nu+2)^n \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ 1 & a-\nu+n & (a-\nu+n)^2 & \ldots & (a-\nu+n)^n \end{vmatrix}, \text{ or } E_{n+1} \text{ say,}$$

and thus such that

$$(E_{n+1})_{\nu=n} = D_{n+1}.$$

4. Now operating on the columns of E_{n+1} as we did in the case of D_{n+1}, the multiplier being $a-\nu$, we obtain

$$E_{n+1} = \begin{vmatrix} 1 & 0 & 0 & \dots & 0 \\ 1 & 1 & 1(a-\nu+1) & \dots & 1(a-\nu+1)^{n-1} \\ 1 & 2 & 2(a-\nu+2) & \dots & 2(a-\nu+2)^{n-1} \\ \dots & \dots & \dots & \dots & \dots \\ 1 & n & n(a-\nu+n) & \dots & n(a-\nu+n)^{n-1} \end{vmatrix}$$

$$= n!\begin{vmatrix} 1 & a-\nu+1 & \dots & (a+\nu+1)^{n-1} \\ 1 & a-\nu+2 & \dots & (a-\nu+2)^{n-1} \\ \dots & \dots & \dots & \dots \\ 1 & a-\nu+n & \dots & (a-\nu+n)^{n-1} \end{vmatrix},$$

where the last-written determinant, though not superficially identical with E_n, having $a+1$ where E_n has a, gives up exactly like E_n the factor $(n-1)!$, so that we finally reach

$$\begin{aligned} E_{n+1} &= n!\,(n-1)! \quad \dots \quad 2!\,1! \\ &= D_{n+1}. \end{aligned}$$

5. Since in E_{n+1} the variables a and ν nowhere occur unless in the association $a-\nu$ we shall lose nothing in generality by changing $a-\nu$ into K. This means that our final result is better written

$$\begin{vmatrix} 1 & K & K^2 & \dots & K^n \\ 1 & K+1 & (K+1)^2 & \dots & (K+1)^n \\ \dots & \dots & \dots & \dots & \dots \\ 1 & K+n & (K+n)^2 & \dots & (K+n)^n \end{vmatrix} = n!\,(n+1)! \quad \dots \quad 2!\,1!$$

6. If, however, we would not neglect the idea of the *difference-product* and the expression of it as a determinant, namely, for example,

$$\begin{aligned} &\text{difference-product of } a, b, c, d \\ &= (d-c)(d-b)(d-a)\cdot(c-b)(c-a)\cdot(b-a) \\ &= |\, a^0b^1c^2d^3 \,|, \\ &= |\, (a+x)^0(b+x)^1(c+x)^2(d+x)^3, \end{aligned}$$

much trouble and space would be saved and made available for more important things. Thus, the determinant of § 5, being

$$|\, K^0(K+1)^1 \quad \dots \quad (K+n)^n \,|,$$

is seen to be the difference-product of K, $K+1$, . . . , $K+n$, and therefore to be the difference-product of 0, 1, 2, . . . , n,

i.e., $\quad 1\cdot 2 \dots n \times 1\cdot 2 \dots (n-1) \times \dots \times 1\cdot 2 \times 1$

or $\quad n!\,(n-1)! \dots 2!\,1!$

7. A quite recent instance of such neglect occurs in the last issued part of the *Bull. Soc. Math. Grèce*, pp. 24–26, where the determinant considered, being

$$| \nu^0 . (\nu+\mu_1)^1 . (\nu+\mu_2) \ . \ . \ . \ . \ (\nu+\mu_m)^m |,$$

is equal to the difference-product of $0, \mu_1, \mu_2, \ldots, \mu_m$ and therefore without more ado

$$= \mu_1\mu_2 \ . \ . \ . \ \mu_m \times \text{diff.-prod. } (\mu_1, \mu_2, \ldots, \mu_m).$$

Unfortunately, in the *Zentralbl. f. Math.*, vi, p. 99, it is reported as being independent of the μ's and equal to $1\,!\,2\,!\,3\,! \ . \ . \ . \ m\,!$.

8. Another instance, not quite so recent but still more curiously interesting, is to be seen in the *Giornale di Mat.*, lxviii, pp. 177–200, the subject there being the obtaining of one of the two simpler determinant expressions for the square of the difference-product, namely, that ordinarily arrived at by making a slight alteration in the form of the multiplier before using it, for example,

$$| a^0b^1c^2 |^2 = - \begin{vmatrix} 1 & a & a^2 \\ 1 & b & b^2 \\ 1 & c & c^2 \end{vmatrix} \times \begin{vmatrix} a^2 & a & 1 \\ b^2 & b & 1 \\ c^2 & c & 1 \end{vmatrix}$$

$$= \begin{vmatrix} 3a^2 & b^2+ab+a^2 & c^2+ac+a^2 \\ a^2+ba+b^2 & 3b^2 & c^2+cb+b^2 \\ a^2+ca+c^2 & b^2+cb+c^2 & 3c^2 \end{vmatrix}.$$

In keeping with the new procedure a new name is bestowed on the resulting determinant, namely, *pseudo-vandermondian*.

9. In view of our regret as above expressed it may be well to add that the fullest available account of the difference-product and its relatives is to be found in the chapter on Alternants in Metzler's *Treatise on Determinants* (pp. 321–363): and that the use of the other simple form of its square is specially dealt with by L. Baur in *Math. Annalen*, lii, pp. 113–119.

RONDEBOSCH, S. AFRICA,
24th June 1933.

NOTES ON *RHOPALOTA APHYLLA*, N. E. BR.

By R. S. Adamson.

From the Department of Botany, University of Cape Town.

(With eight Text-figures.)

Rhopalota aphylla is a small succulent plant of aquatic or subaquatic habit, recently described and figured by N. E. Brown (2, 3).

The plant is of interest owing to its aquatic habitat, very limited distribution, and vegetative form.

The plant is confined to the summits of the higher peaks in the Cedarberg, where it was originally discovered in 1896 by Schlechter. Since then it has been collected on the summit of Tafelberg (6500 ft., 1967 m.) by K. H. Barnard, Mrs. M. R. Levyns, and others, and also on Great Krakadouw Peak (5719 ft., 1743 m.). The plant was regarded as a species of *Crassula* till Brown established the new genus.

The summit of the Tafelberg is built up of almost horizontal beds of sandstone which have been weathered into a series of hollows with intervening ridges. These rocky hollows form basins in which water collects and frequently remains for considerable periods. It is in them that this plant is found. The soil is quite shallow, up to 3 cm., and consists of sand bound by the numerous roots of the plant. A quite appreciable quantity of organic matter may be accumulated and the soil become quite black. The plants are social and occur in large numbers associated together though each is a separate unit.

On the Tafelberg the plant is very frequently submerged, often to a depth of 30 cm. When the material which forms the greater part of this investigation was collected the plants were submerged under 20–25 cm. of water which had ice on the surface at the edges of the pool. Even in April, at the end of the dry season, J. B. Cuthbert reported water in these pools.

In the station where the plant was found, on Great Krakadouw Peak, about 15 miles north of Tafelberg, the conditions were much less hydrophytic. The plants grew in a shallow basin that would hold water only for short periods and never to a depth of more than about 5 cm.

The material for this investigation was collected in part on Great

Krakadouw Peak, and in part on Tafelberg. The latter was collected by Mrs. M. R. Levyns and was part of the material conveyed to Kew and on which Brown made his descriptions.

The plant is inverted bottle-shaped with a slender stem widening upwards. The tip is blunt and very slightly two-lobed with the stem apex deeply sunk. The plant may attain a height of 2 cm. though 1–1·5 cm. is more usual. At the top it may attain a diameter of 5–7 mm. When growing in aquatic conditions the plants stand up above the soil and are bright green, but under drier conditions they are brownish or red in colour and almost buried in the soil. In the Krakadouw station the tips of the shoots were level with the surface.

The plant is described as leafless, but this only applies to the absence of any spreading leaves. The stem bears two connate leaves which extend well beyond the stem apex which is at the base of a tubular cavity. In young plants this cavity is flattened, the long axis being at right angles to the plane of the leaves. The shape becomes variously modified in older plants where growth from the apex has taken place.

Continued growth from the apex and axillary buds forms shoots similar in form to the original, but smaller. These continued growths are short-lived, the main shoot alone being persistent. Accessory buds are formed and hence a series of innovations can be produced. These innovations are formed more freely in submerged plants. The flowers are terminal on either the first or more often subsequent continuation shoots.

Flowers are formed in summer when the plants are not submerged or at any rate not deeply so. Plants collected in September flowered freely in the following December and January. The material collected on Krakadouw in May produced a few flowers when watered, but the majority of the flowering shoots were dried up and dead. Mrs. Levyns informs me that she has collected flowering plants growing under water; it seems probable that these had been recently submerged.

The base of the stem produces a large number of slender roots. The roots may attain a length of 2 cm. but are not much branched. The basal root producing part in older plants is wider than the stem above.

This plant though a succulent is definitely hygrophytic. When kept dry shrivelling soon occurs. With the exception of very young seedlings, the plants remain erect when shrivelled. Shrinkage produces grooves and crumplings in the upper parts. Shrinkage does not cause death unless very prolonged, recovery occurs when water is again available. No exact data are available as to the length of time during which this wilting can be continued. Plants growing in their own soil, collected on Tafelberg, were kept in the laboratory in a glass dish to which water was added from time to time. These remained active and flourishing for two years. After

this they were left unwatered for six months. This caused death. When the soil was subsequently watered a number of seedlings came up.

Some plants entirely separated from soil were kept dry at ordinary room conditions for three weeks, after which they recovered completely when resupplied with water.

Some preliminary experiments have been carried out on the water relations of the plant. The material available at the time was not sufficient to allow of a complete investigation.

When the external supply of water is limited or cut off the plants at first transpire rapidly and lose a large proportion of their water-content. Afterwards the water loss becomes very small. As one example, plants were washed out from the soil and placed on glass slips in the laboratory. Water loss was determined by loss of weight. The following results were obtained, each set is the average of fifteen plants. The figures are taken for 24-hour periods and are expressed as percentages of the initial value.

	A.	B.	C.
First day . . .	100	100	100
Second ,, . . .	2·3	3·0	11·7
Third ,, . . .	1·3	2·2	. .

During the experiment the conditions were uniform. The plants were placed in a window without direct sunlight. The temperature ranged from 13·3° C. (54° F.) to 16·6° C. (62° F.) and the relative humidity from 75 to 82.

The plants were kept till shrinkage had definitely commenced, when their water-content had fallen to 30 per cent. of the original. One set replaced in water showed complete recovery in 12 hours. The degree of shrinkage in these experimental plants was much less than is often withstood both in amount and duration.

The very rapid loss for a short period shown by these plants is quite comparable to a non-cuticularised plant and quite unlike the behaviour of many succulents (*cf.* 4).

Absorption of water is carried on by both roots and aerial portions, indeed the latter are quite efficient in this respect (*cf.* 5, 6). As a preliminary test of this a number of plants were washed out from the soil and allowed to dry at room temperature for three days. They were then placed in water, one-half with the roots in water, the others inverted with their tips in water. The latter recovered their turgor more quickly, taking 3 hours as against 6–8 for the others. This experiment does not mean that surface absorption is the main source as the dried roots of these plants took an appreciable time to become rewetted.

In general structure the plant is rather simple. The stem is traversed by a single vascular strand which above gives off a branch to each leaf. The leaf bundles pass upwards in a curve near the inner side and terminate in hydathodes which are on the inner face not terminal. The two leaf traces separate at the same point. In plants with continued growth the vascular strand continues beyond this point. At the base the vascular strand ends near the top of the root-producing region. Numerous branches extend in all directions to the roots (fig. 1).

The upper swollen part is made up of the two connate leaves which are only free at the blunt tips. In this part the epidermis has a very thin cuticle. The epidermal cells are rectangular and transversely elongated.

Fig. 1.—Outline of longitudinal section of a plant, showing course of the vascular bundles. × 7.

In plants from Tafelberg the cells have wavy walls but straight ones in those from the drier habitat on Krakadouw. Stomata occur on the epidermis both outside and on the inner face. They are most numerous at the tips where counts numbered 14 per sq. mm. The stomata are of the type usual in Crassulaceae with several small cells around the guard cells (7). In the lower parts and on the stem stomata are wanting and the epidermal cells are elongated vertically.

The internal tissue of the leaf portion is made up of large thin-walled cells containing chloroplasts. The cells are easily plasmolysed. No visible swelling up occurs when sections are placed in water. Intercellular spaces occur between these cells. In the lower portions of plants from Tafelberg the inner cells are separated by radial cleft-like spaces (fig. 2); these large spaces are absent in the Krakadouw specimens.

The increase in size of older plants is brought about mainly by increase in the size of these cells. Some cell division occurs in those nearest the epidermis, but very little.

The hydathodes on the inner side near the top of the tubular cavity are of the usual epitheme type: each opens by a number of small stomata. The small-celled hydathode tissue extends for some distance.

Below the hydathode the vascular bundle has the form of a ring with a central pith area. About one-third down the leaf this ring opens on the adaxial side. In the lower third of the trace the bundle becomes smaller: the xylem forms a curved strand, with a single protoxylem in small plants, or three or more in larger ones.

The bundles curve in sharply and unite with one another and with the

stem bundles, if any. Immediately below the point of junction the vascular strand is flattened with the long axis in the plane of the leaves. Lower down it becomes circular with a median xylem with the protoxylems in the centre (fig. 3). The appearance in transverse section is like that described for some very young seedlings (*cf.* 1, fig. 5, F). This circular condensed strand continues right through the stem. It is bounded throughout its length by a definite sheath.

The union of the two leaf traces is usually less than one-third half-way down the length of the swollen region. This passes gradually into the

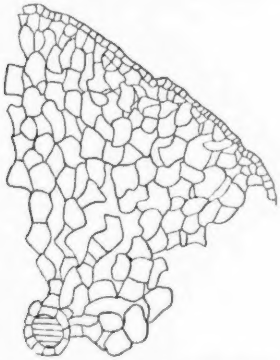

Fig. 2.—Part of transverse section through the swollen region. ×32.

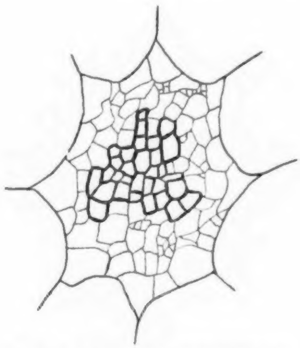

Fig. 3.—Vascular strand from the middle region. ×370.

slender stem which has about a third to a fifth its diameter. In the narrow cylindrical part the structure is quite hydrophytic (fig. 4). The cortex is in the form of radial rows of cells separated by wide intercellular spaces. There are one or two layers of cells without large spaces under the epidermis. Even in plants from Krakadouw this structure is developed though the spaces are somewhat smaller and three or four layers occur below the epidermis.

The basal region is sharply separated from the stem both by its structure and by the presence of roots all over its surface. The ground tissue here is made up of cells arranged in roughly radiating lines: near the outside the cells are regular and close together, but in the interior loose and rather irregular in shape. The surface is covered by cork which arises from a superficial cambium. The cork cells are shallow and flat with the tangential walls slightly thickened. Except in the most recently formed parts the cells of the cork become compressed and form an apparently structureless layer.

The vascular strand from the stem ends near the top of this cork-covered base. Numerous and irregularly arranged root traces run from the main

vascular strand in all directions. The root traces may be slender strands supplying single roots or stouter branches giving supplies to several. The numerous root traces passing out from the end of the stem strand give the appearance of its ending in a swelling (figs. 1, 6).

The roots are all adventitious and arise from the surface cambium layer. The roots are apparently short-lived and new ones are continually being formed. The new roots are not produced in any definite position or succession, but appear at any part of the surface of the base. It is probable that the roots, though persistent as fixing organs, do not survive conditions of drought. Plants which had been in dry soil, subsequently watered, when

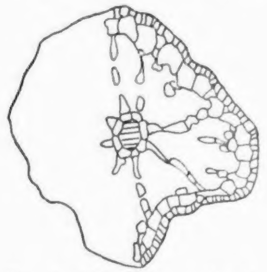

Fig. 4.—Transverse section of the stem. ×40.

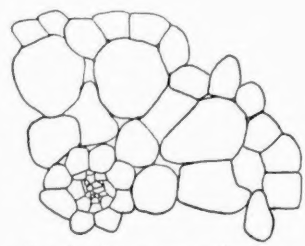

Fig. 5.—Transverse section of a root. ×260.

sectioned had numerous roots just forming, but those existing all dried up and shrivelled.

The root in its growth bursts through the cork on the surface. When a primordium arises cell division occurs in the cells to the inside which form a procambium and finally a vascular trace connecting the new root with the vascular system of the plant.

The roots themselves are slender with a small central cylinder which is 2- or 3-arch. The vessels are very small (fig. 5).

In small plants the basal region is a small inverted dome about the same diameter as the stem above, but in older plants it may become considerably wider and is often irregularly lobed on the surface (fig. 6).

The cambium layer is not very definite in form in young plants, but in older ones has the typical arrangement of cells in radial rows.

The explanation of this rather unusual arrangement at the base was obtained by an examination of seedling plants.

The smallest seedlings examined were about 5 mm. long. These plants had just made their appearance above the soil. In some the empty testa was still associated.

These seedlings have the same general form as adult plants though on

a small scale. They differ, however, in having the stem continued downwards into a slender, unbranched, translucent, primary root (fig. 7). This root is provided with root hairs and tapers to a narrow point. It is often quite short, though in a few seedlings it was as much as 3·5 mm.

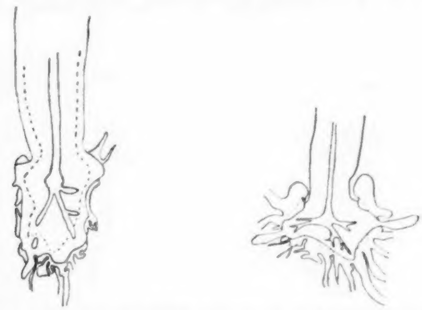

FIG. 6.—Outlines of median longitudinal sections of the bases of old plants. × 9.

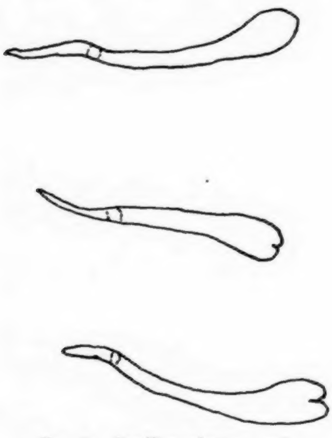

FIG. 7.—Seedling plants. × 8.

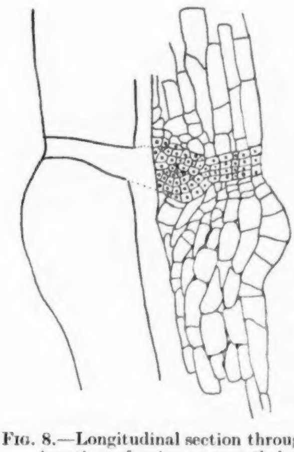

FIG. 8.—Longitudinal section through junction of primary root (below) and stem, showing meristem layer with initiation of an adventitious root. × 175.

In the seedlings examined the vascular strand of this primary root never becomes fully differentiated. It is cast off before this occurs. This is brought about by the formation of a meristem layer across the proximal end of the root which extends right across the axis (fig. 8). At first this is a single layer of cells forming a saucer-shaped plate lowest in the middle.

Cell division occurs and results in cork cells on the lower side and additional ground tissue above. Adventitious roots arise from this layer and their formation commences while the primary root is still functional.

It is from the continued growth of this layer that the basal region of the plant is formed. The meristem layer continues activity throughout the life of the plant and provides the continued additions of roots.

Rhopalota was originally described as an annual (2), though in his later description Brown calls it a perennial. The aerial parts are limited to two leaves with quite ephemeral continuations. But owing to its capacity for forming accessory buds and especially to the continued secondary development below ground the plant undoubtedly persists through several seasons.

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THE MORPHOLOGY OF *BALANOGLOSSUS CAPENSIS* (GILCHRIST), A SPECIES OF ENTEROPNEUSTA FROM FALSE BAY.

By C. von Bonde.

(With seven Text-figures.)

Introduction.

This species was discovered by the late Professor J. D. F. Gilchrist during shore collecting, and its external features were described by him in the Marine Investigations of South Africa, vol. v, p. 172 (1908), together with some other forms of Hemichorda from South Africa. In the present paper the internal anatomy is dealt with, but a few details about the external structure are added.

Habitat.—This species occurs at or near low water, generally in coarse sand or gravel, in False Bay, near the Marine Biological Station, St. James.

External Features (fig. 1).

Size.—The length varies from about 80–130 mm. in the normal expanded condition. The relative sizes of the various regions of the body do not vary very much. Even the caudal region, which in other species has been found to vary so greatly, was about the same proportionate length in these specimens, probably owing to the fact that this species does not show a tendency to break up so markedly as in other species.

Colour.—The colour of the proboscis is pale chrome-yellow, uniform except when in the expanded condition, when the longitudinal muscles appear as distinct stripes. The collar is of a paler yellow with a thin band of white pigment, followed by two thin yellow streaks. The trunk is also pale yellow, the gonads being bright yellow with a dark-reddish genital streak. The colour of the hepatic caeca varied considerably, being, however, always dark brown in the central region. Anteriorly and posteriorly they were more or less light, sometimes pinkish. The tail region has three yellowish lines along the whole length of its upper surface.

Body Regions.—1. *Proboscis*: The proboscis is of the usual size and shape, being somewhat broader than long, conical, with the apex bluntly rounded. During life it appears somewhat longer and often bent in various

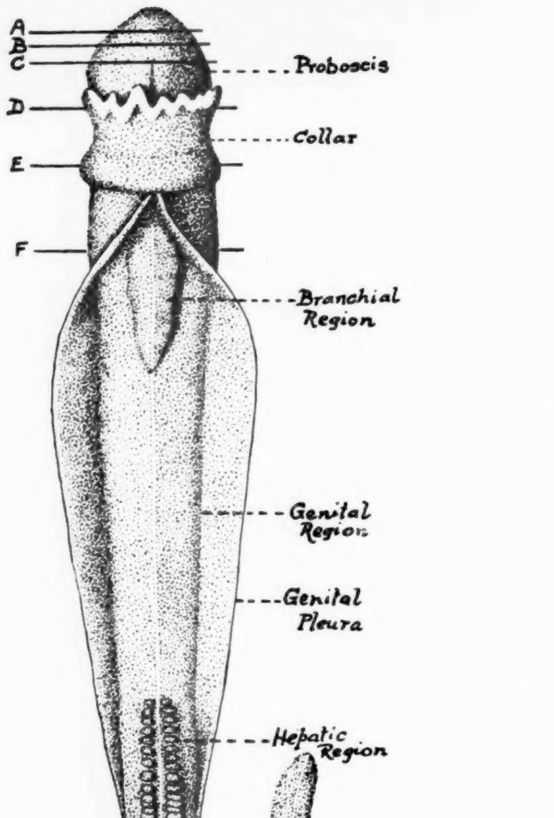

FIG. 1.—*Balanoglossus capensis* (Gilchrist). Dorsal view. × 4.

directions. A slight notch occasionally appeared on its posterior dorsal surface. In some conditions the longitudinal muscles of the proboscis were observed in distinct bundles.

2. *Collar*: The dimensions of the collar are also normally fairly constant, its length being usually equal to that of the proboscis. Its breadth is slightly less than its length, being narrow in the middle. There are five distinct regions discernible. The first region is the free anterior margin, occurring as a folded frill, and which occupied nearly one-half of the total length of the collar. The next region is in the form of a narrow ring. The ring is followed by a thin band of white pigment in the form of a circular streak. Then follows another thin streak, and lastly, where the collar joins the trunk, is the fifth region also in the form of a yellow streak.

3. *Trunk*: The trunk region may be subdivided into three regions, viz.:

(*a*) Branchiogenital Region.
(*b*) Hepatic Region.
(*c*) Abdominal Region.

(a) *Branchiogenital Region.*—This region is characterised by the occurrence of the genital pleura or wings, attached anteriorly to the collar. The pleura are well developed both in length and breadth. The maximum breadth is at the posterior end of the gills. When spread out it is a little over twice the length of the proboscis. The posterior extremity could not be exactly determined, as from the posterior end of the gills the pleura gradually diminish in size and lie alongside the hepatic caeca in mere ridges. The point of transition from distinct pleura to ridges is at about the middle of the hepatic caeca. At this point, also, the gonads ended in most specimens. There is, however, no abrupt transition as in some other species. The free edges of the genital wings are always in contact with each other where they join the collar. They are transparent throughout, in marked contrast with the gonads. In the trunk region they meet each other above the intestine behind the gills, this region being also clear and transparent. The apertures of the gonads are in the form of a fine genital streak, dark reddish in colour, which occurs along the centre of the gonads. The gonads are bright yellow. The genital wings usually meet each other dorsally over the body, though often folded outwards so as to expose the gills; their point of origin is the dorsolateral region of the body.

The branchial region is comparatively small, being equal to the combined length of the proboscis and collar. This length was constant in the specimens examined. In breadth it is fairly uniform till near the posterior end, when it abruptly tapers off to a point, and was often observed to pass under the joined bases of the genital pleura, about 1/7th of its total length being thus hidden. At its widest anterior part it is about half the length of the proboscis. About 50 gill-slits or pores were counted in the deep

furrow at each side of the row of gills. In the living animal the anterior of these were slit-like, being more than twice as long as broad. Towards the posterior part of the gill region they become more circular, and the most posterior were almost circular, sometimes square. In preserved specimens all the openings are decidedly elongate.

(b) *Hepatic Region.*—In this region there are about 60 pairs of hepatic caeca. Anteriorly the caeca are less definite and more widely set apart, about 12 of them being between the genital folds, by which a few of the anterior of the twelve may be hidden. Farther back they are normally in pairs, symmetrically placed, one on each side of the body, but in extensions of the body they are often seen to interdigitate, thus alternating on each side. Posteriorly they gradually diminish, the whole length of the hepatic tract being equal to the length of the genital ridge or half of the tail region.

(c) *Abdominal Region.*—This region is a little less than half the total length and does not vary much in thickness, being about equal to that of the middle of the hepatic region, which was a little over half the diameter of the collar. The most prominent feature is the presence of three lines running along nearly the whole length of the upper surface, the central one being a thin yellowish streak, which commences at about the middle of the hepatic region and continues to near the extremity of the tail. In other species in which such streaks are described they are situated in a groove which passes through the "islet"-like cross-bands of glandular tissue. Here, however, these bands pass over them so that epidermal furrows were absent on the dorsal surface, one of the most distinctive characteristics of the species.

On the ventral side the yellowish ventral nerve cord occurs, and interrupts the glandular patch, throughout its whole course, from collar to anus; in contrast with the dorsal nerve it thus lies in an epidermal groove.

On the dorsal side of the tail these glandular patches of the epidermis are of no great length transversely to the body, but on the ventral side they appear almost like annulations.

Internal Anatomy.

The details of the internal anatomy were observed by the examination of series of sections, both transverse and longitudinal, cut through the above-mentioned three regions of the body, and the structure of each region may thus be described in detail.

1. *Proboscis.*—The epidermis of the proboscis laterally and ventrally has a thickness of about ·11 mm., while nearer the posterior dorsal end, where the slight notch occurs externally, it gradually increases in thickness till along the mid-dorsal line it attains a length of ·25 mm. In a transverse

section the epidermis of the notch appears slightly folded externally, while internally it has almost a semi-circular outline. The epidermis is bounded internally by a triple layer about ·03 mm. in thickness composed of the nerve layer, a very thin boundary membrane, and the layer of circular muscles. This triple layer becomes about ·05 mm. thick on either side of the notch and then thins out to about ·015 mm. on the internal surface of the notch, made up of equal thicknesses of the two layers. Near the proboscis neck the external notch disappears, and then the various layers are restored to their normal thicknesses. The longitudinal muscles are formed into radially arranged bundles extending from the layer of circular muscles to about three-quarters of the distance between them and the centre of the proboscis. Each radial bundle has a broad base, and generally tapers towards its central extremity, where it ends in a flattened or slightly rounded surface, thus having the appearance of a slender isosceles triangle, horizontally truncated near the apex (fig. 2, *r.m.*). The central ends of the radial bundles appear to lie in a roughly circular membrane of connective tissue, broken at intervals. The fibres are embedded in connective tissue. Anterior to the notochord and other organs forming the central complex of the proboscis the central part of the proboscis is filled with connective tissue which more posteriorly surrounds these organs. The fibres are shown running between the circular muscle layer of the dorsal and the posterior part of the proboscis, at the posterior end of the proboscis. Here the radial fibres have the form of well-developed rods.

The *splanchnic epithelium* of the proboscis appears in the form of a membrane, the nuclei of whose cells are deeply stained, so much so that they appear quite distinctly massed together into a definite border on the outer side of the glomerulus. There is a layer of tissue lying on the outer surface of the splanchnic epithelium of a spongy appearance, which appears thickest laterally, and thins out dorsally and ventrally where it appears to be continuous with the connective tissue on the outer sides of the septa of the proboscis coelom. In these regions the splanchnic epithelium thins out so that the nuclei are scattered about and do not form such a distinct border as laterally.

The *proboscis coelom* (figs. 2, 3 A and B, *p.c.*) is well developed, and surrounds the organs of the proboscis anteriorly. Scattered elements of connective tissue appear in the coelom in close proximity to the splanchnic epithelium. Towards the proboscis neck the coelom is divided dorsally by the pericardium and dorsoventral muscle fibres, and ventrally by the ventral optum into two equal parts. The dorsoventral muscle fibres appear in a transverse section in the form of an elongated isosceles triangle which forms the pericardium and encloses the heart or ventral blood sinus of the proboscis ("centraler Blutraum d. Eichel"—Spengel) and divides the

proboscis coelom into two dorsolateral proboscis pouches. The ventral septum (*v.s.*) arises ventrally to the notochord and extends downwards. It consists of a central membrane with blood spaces, and the sides are composed of connective tissue directly continuous with the spongy layer external to the splanchnic epithelium above described. The ventral septum divides the proboscis coelom into two ventrolateral pouches (fig. 3,

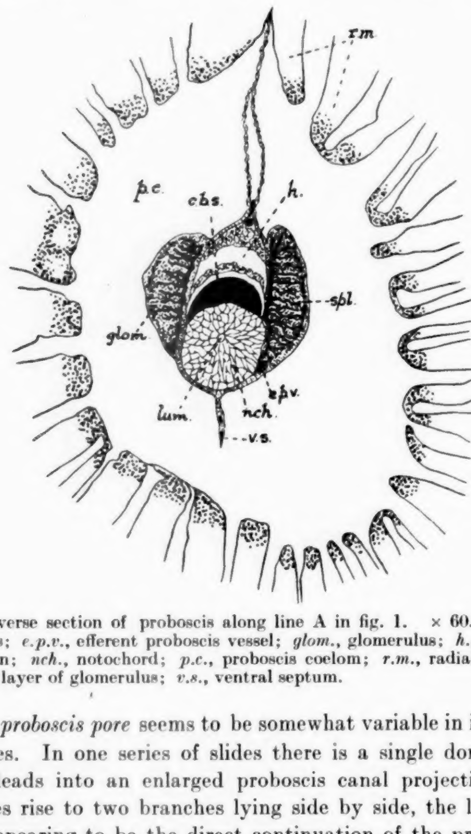

FIG. 2.—Transverse section of proboscis along line A in fig. 1. × 60. *c.b.s.*, central blood sinus; *e.p.v.*, efferent proboscis vessel; *glom.*, glomerulus; *h.*, heart bladder; *lum.*, lumen; *nch.*, notochord; *p.c.*, proboscis coelom; *r.m.*, radial muscles; *spl.*, splanchnic layer of glomerulus; *v.s.*, ventral septum.

v.p.c.). The *proboscis pore* seems to be somewhat variable in its occurrence in this species. In one series of slides there is a single dorsal proboscis pore which leads into an enlarged proboscis canal projecting forwards, where it gives rise to two branches lying side by side, the left being the larger and appearing to be the direct continuation of the proboscis canal itself, the smaller right branch being a lateral projection which does not continue as far forwards as the left. In another series there is a single proboscis pore occurring dorsolaterally on the right side and leading into a single proboscis canal lying on the right side of the central complex.

The *notochord* (*nch.*) is very well developed. Anteriorly it occupies the

middle region of the proboscis and has the form of a solid rod of cells. Its shape appears to be very variable, and the following variations were observed:—

(*a*) In one specimen a transverse section of the notochord showed it

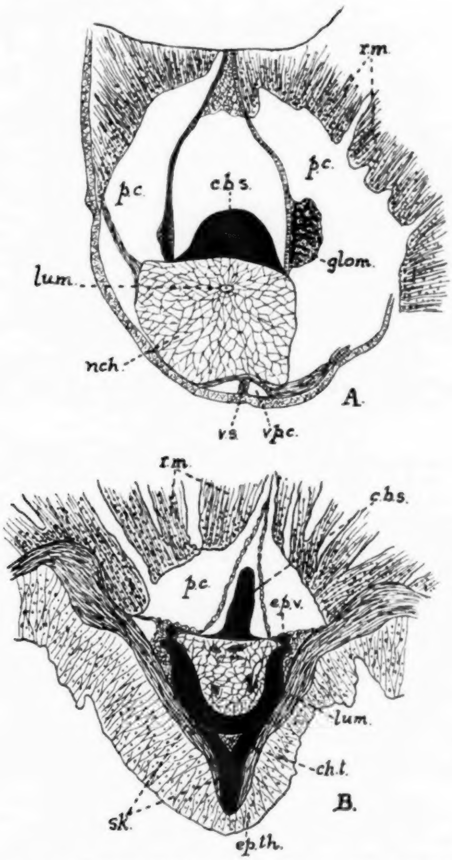

FIG. 3, A.—Transverse section of middle part of proboscis along line B in fig. 1. × 60. Lettering as in fig. 2. *v.p.c.*, ventral proboscis coelom. B.—Transverse section along line C in fig. 1. × 60. *ch.t.*, chondroid tissue; *ep.th.*, epithelium of throat; *sk.* skeleton.

to be laterally compressed at its anterior end, and this same specimen had a groove in the horizontal plane at the anterior end, so that in section the anterior end of the notochord appeared as consisting of two almost equally

developed parts lying one above the other (fig. 4, A). The glomerulus occurs between these two parts and around them, but appears better developed on the left side. This is more apparent where the groove ends

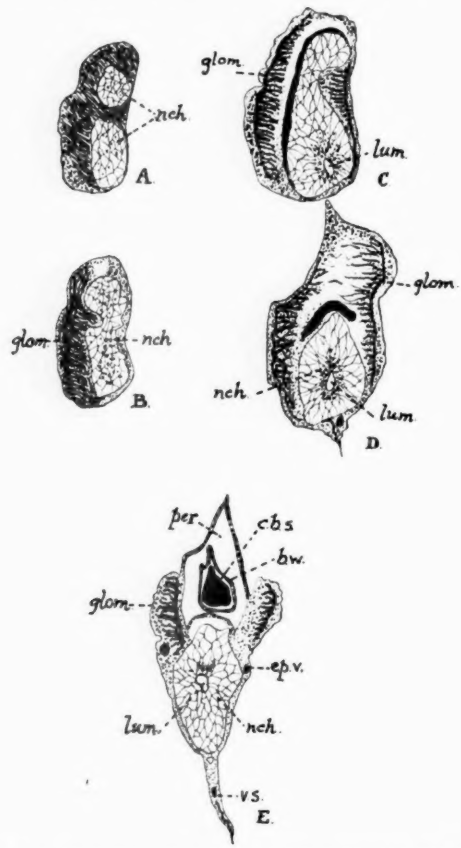

FIG. 4, A–D.—Successive transverse sections of the notochord, taken from the same series, showing changes in shape. × 60. E.—Transverse section of central complex of proboscis taken from another series. × 60. *b.w.*, bladder wall; *per.*, pericardium.

and the notochord is single, having an almost rectangular shape, the sides being slightly undulose and the ends rounded. Here the glomerulus is very well developed on the left side, while on the right it merely forms a thin membrane (fig. 4, B). The cells of the notochord are fairly large and irregular, the lumen first occurs some distance from the anterior end of the

notochord in the form of an oval opening situated near the ventral part of the chord. Here the notochord has acquired a deep indentation on the right side, which is filled by the glomerulus (fig. 4, C). Farther back the notochord assumes the shape of an isosceles triangle whose apex is dorsal and whose basal angles are rounded. The glomerulus here appears equally developed on both sides of the notochord. The shape of the notochord in this region changes so suddenly from the almost rectangular shape above described that it appears as though the upper part of the notochord as shown in fig. 4, C, disappears, thus giving rise to the triangular shape (fig. 4, D).

(*b*) In another series of transverse sections the notochord appears first in the shape of an oval. Then, as we proceed backwards, it becomes almost rounded in shape and then once again oval, the long axis of this oval being in the same vertical plane as that of the anterior end, but the short axis is less than that of the first (fig. 4, E). The lumen seems to appear in this particular series at the point of transition between the circular outline and the oval. In this case the glomerulus was equally developed on both sides in the form of two horns on the dorsolateral aspects of the notochord. Towards the neck of the proboscis the notochord becomes semicircular in shape, the flattened diameter being dorsal. This variation seems to be the commonest form of the notochord, and appeared in the majority of sections prepared and examined.

(*c*) This series happened to be made in an oblique plane which ran parallel to a line passing through the middle of the dorsal part of the proboscis and the anterior part of the ventral collar region. In the notochordal region a section along this line passes just anterior to the commencement of the skeleton, and shows clearly the ventral proboscis cavity as a small round space immediately below the notochord. In this series the notochord anteriorly has a shape similar to that described in (*b*) above, but in this region it has assumed roughly an oval outline, the long axis here being horizontal, and it lies in contact with the nervous tissue which surrounds the ventral proboscis coelom. This case is probably a variant of (*b*), the apparent difference being due to the oblique plane of the section.

In all these and other cases examined only one lumen was apparent in the substance of the notochord, and the "blind sac" described by Spengel does not appear at all.

The *proboscis skeleton* is similar in appearance to that of most described species. It consists of an anterior "end-plate" in the form of a half cylinder, in which the notochord lies. The anterior end does not extend far into the proboscis itself, but commences just in front of the proboscis neck. A short distance from the anterior end the skeleton develops a median ventral keel, so that in a transverse section it has the appearance

of a "Y" with the diverging limbs almost semicircular in outline (fig. 3, B, *sk.*). The extremities of these limbs are in line with the dorsal surface of the notochord, so that the notochord completely fills the half cylinder formed by this part of the skeleton. The keel itself appears to be separated from the limbs by a thin band of "chondroid tissue," and is wedge-shaped

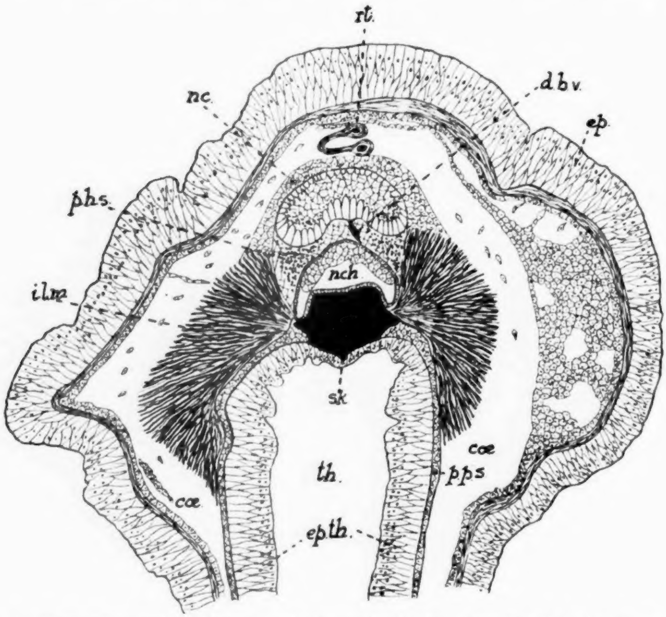

FIG. 5.—Transverse section through anterior part of collar along line D in fig. 1. × 60. *coe.*, coelom; *d.b.v.*, dorsal blood-vessel; *ep.*, epidermis; *i.l.m.*, inner longitudinal muscle of collar; *n.c.*, nerve cord; *p.h.s.*, perihaemal space; *p.p.s.*, peripharyngeal space; *rt.*, root; *th.*, throat.

with a small groove dorsally, which is completely filled by "chondroid tissue." Posteriorly the semicircular limbs appear to decrease in size and appear as a single rod lying over the keel, but completely separated from it. This rod then decreases in size gradually, while the ventral part of the keel appears also to diminish to a lesser degree; the dorsal part of the keel remains constant (fig. 5) and gives rise to two diverging limbs posteriorly, while the ventral part of the keel completely disappears. The keel, however, projects strongly into the antero-dorsal end of the throat, where it is covered by a well-defined layer of epithelium. Just above it the lumen of the notochord is well shown (figs. 5 and 6, *lum.*). The two posteriorly diverging limbs of the skeleton appear first near the posterior end of the

first zone of the collar region, the body of the skeleton becoming roughly rectangular, the long axis being horizontal. Then grooves appear mid-dorsally and mid-ventrally, deepen, until ultimately the two "legs" are formed. Immediately above the body of the skeleton the notochord is

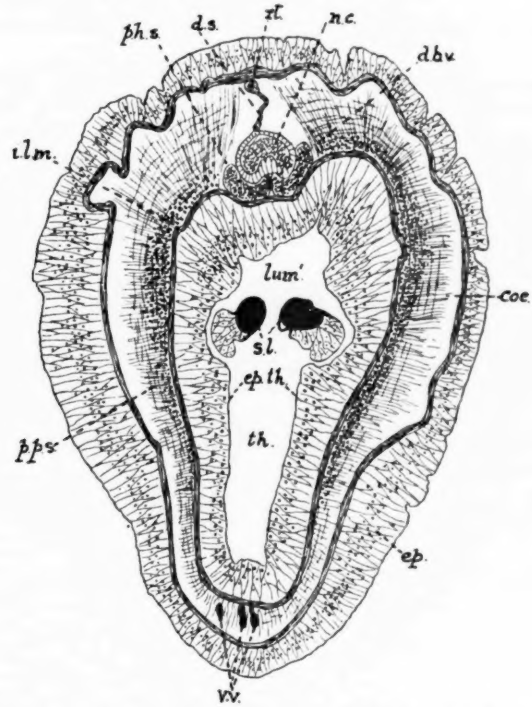

FIG. 6.—Transverse section through posterior part of collar, along line E in fig. 1. × 30. *lum.*, opening of lumen of notochord into throat; *s.l.*, skeletal legs; *v.v.*, ventral blood-vessel of collar.

well shown and its lumen well developed. As this series is traced backwards, the two "legs" of the skeleton arise, and then when they diverge the lumen of the notochord is in open communication with the throat, while the epithelium of the throat is continuous with the notochord. The two "legs" or "nuclei" separate more and more, each being a solid rod covered by thick epithelium on the ventrolateral surface (fig. 6 *s.l.*). The "legs" terminate just below the projection of the anterior ends of the gills into the throat.

The *pericardium* has the same essential structure as in other described

species of the genus. It is in the form of a completely closed sac, having no communication with the proboscis coelom or with the vascular system. Anteriorly it commences a short distance behind the commencement of the notochord. The sides are about equally long, and converge to form a very acute apical angle, the base being concave (fig. 2). The apex of the pericardium extends for some distance between the radial muscles of the proboscis, which appear separated in this region, but does not reach the layer of circular muscles. Near the posterior end of the proboscis, however, the sides of the pericardium, having reached the circular muscles and the boundary membrane of the epidermis, gradually separate dorsally to become separately attached to the boundary membrane (fig. 3, A). From this point it gradually diminishes, until it completely disappears in the neck of the proboscis. The base of the pericardium lies over the ventral blood sinus (fig. 2, *c.b.s.*). The pericardial cavity contains a cellular tissue which runs right through its entire length. This tissue sometimes assumes a membraneous appearance, appearing in transverse section to run parallel to the sides of the pericardium. In the anterior region the ventral wall of the pericardium is folded into a cylindrical bladder occupying the central part of the pericardium and being completely closed, having no communication with the pericardial space in this region and enclosing the central blood sinus (fig. 4, E, *c.b.s.*). Farther back this bladder opens ventrally, and is placed in communication with the central blood sinus in this position, lying over the notochord and in close contact with it.

The *glomerulus* (figs. 2, 3, 4, *glom.*) forms a cap over the anterior end of the pericardium and notochord. Proceeding backwards from the anterior end of the notochord we find the glomerulus becoming restricted to two lateral masses lying on either side of the central proboscis complex. These lateral masses appear in most sections to be equally well developed, while in some one side is much more developed than the other. Some variations of the glomerulus were cited in the description of the notochord above. The cells of the splanchnic epithelium are easily recognisable, and have already been mentioned. The vessels of the glomerulus present a honeycomb-like system. The efferent proboscis vessels which, according to Spengel, arise at the posterior end of the glomerulus, are well shown in sections passing through the glomerulus, lying at the ventrolateral extremities of the glomerulus as distinct vessels (figs. 2; 3, B; 4, E; *e.p.v.*), which may be traced to near the anterior end of the glomerulus.

2. *Collar.*—The epidermis of this region can also be divided into five zones. The first zone is formed by the folded free margin of the collar and is the largest; the second occupies the region of the circular groove, and is composed throughout its whole depth of darkly-staining gland-cells; the third occupies the region of the circular projection cushion; the fourth forms

the base of a ring furrow, and, like the second, also contains gland-cells and stains deeply; the fifth is formed by the projecting rim forming the posterior boundary of the collar. The second and fourth zones appear similar in construction. The three other zones have the gland-cells only on the outer regions and stain less deeply.

The musculature of the collar appears to be essentially the same as that described in *Balanoglossus* (*Ptychodera*) *australiensis*. In the first zone, just internal to the epidermis, there is a layer of longitudinal muscle fibres well shown in longitudinal sections. In a similar section, just internal to these fibres and occurring in the length of the first zone, is the layer of circular muscle fibres. The inner longitudinal muscles (fig. 5, *i.l.m.*) are well developed, and are separated into distinct bundles by radially arranged fibres passing between the outer and inner walls of the collar on either side of the notochord and skeleton. The radial fibres passing between the inner and outer walls of the collar have the usual inter-crossing arrangement.

The *coelom* has its cavity somewhat reduced in the anterior part of the collar by the presence of spongy connective tissue with radial muscle fibres, which almost completely fill up the coelom. Posteriorly certain spaces are found free from connective tissue between the muscle fibres. These spaces are better developed ventrally than dorsally. In some sections the collar coelom appeared very well developed laterally and ventrally and almost free from connective tissue (fig. 5, *coe.*). Dorsal and ventral septa dividing the collar coelom into two halves are well developed. The dorsal septum appears to arise just posterior to the origin of the two "legs" of the skeleton. A small swelling appears on the dorsal part of the collar nerve cord, and this swelling grows upwards till it meets the nerve-fibre layer of the epidermis. The dorsal septum results and divides the coelom dorsally into two parts. In another series two bodies corresponding to the "roots" (figs. 5, 6, *rt.*) described by Hill (11) appear between the collar nerve cord and the longitudinal musculature of the outer wall of the collar.

These "roots" appear in the region anterior to the origin of the skeletal "legs." In the first case above described the nerve "roots" appeared to be developed from the collar nerve cord, while the septum stretches between the collar nerve cord and the epidermis. The ventral septum only exists in the posterior part of the collar region. The ventral blood-vessel is seen, and posteriorly it seems to grow into a fold in a ventral direction, which eventually becomes united with a vessel fold arising from the subepidermic capillaries to give rise to the ventral septum.

The perihaemal and peripharyngeal spaces, which are extensions of the trunk coelom into the collar region, are well developed. The perihaemal

spaces (figs. 5, 6, *p.h.s.*) enclose a groove in which the ventral half of the collar cord lies. In the centre there occurs a ridge which fits into the groove described below on the ventral side of the nerve cord. The cavities of these spaces are to a great extent filled by radial fibres passing between their dorsal and ventral walls. The peripharyngeal space (*p.p.s.*) is well developed, and passes round the pharynx just outside the epithelium. This space originates anterior to the opening of the lumen of the notochord into the pharynx. The collar canals have the same characteristics as those of other described species of *Balanoglossus*.

The *nerve cord* appears in some transverse sections in the form of a rod whose outline is almost oval, with the long axis horizontal, except for a groove along its ventral side. In others, again, the outline is circular with a similar groove. There does not appear to be an axial canal in the cord, but certain smaller canals occur, the principal ones being on either side near the lateral margins of the cord. Smaller cavities occur irregularly arranged in between the nerve cells, but the total number of canals does not exceed four or five. There is a fibrous layer completely surrounding the cellular portion of the nerve cord (*n.c.*).

3. *Trunk*.—(*a*) The *Branchial Region* (fig. 7) has a thin layer of circular muscles underlying the epidermis. Internal to this is the longitudinal musculature, which is well developed. In the genital pleura the longitudinal muscles of the outer wall (*l.m.*) are better developed than those of the inner wall. The trunk coelom is well developed (*coe.*) and is divided into two parts by the ventral vessel, which extends between the ventral nerve and the epithelium of the alimentary canal.

The *alimentary canal* of the branchial region (fig. 7) is divided into two portions, viz. a dorsal or branchial canal (*br.c.*) and a ventral canal or oesophagus (*oe.*) These passages open into each other by a cleft whose width is varied by the limiting cushions or parabranchial ridges (*p.b.r.*). The branchial canal is of much greater size than the oesophagus. The parabranchial ridges are quite close together for the greater part of their length, in some sections appearing almost contiguous. These ridges are composed of epithelial cells of a greater thickness than the cells lining the rest of the oesophagus. The mid-dorsal region of the branchial canal is composed of deep, narrow cells of epithelium forming the epibranchial strand (*ep.s.*).

The *gill pores* (*g.p.*) are narrow, oblique slits opening into the dorso-laterally placed longitudinal grooves. The anterior ends of the gill zones project for some distance into the pharynx in the collar region and are well shown in transverse sections of the posterior part of the collar region. These projections lie dorsal to the "legs" of the skeleton in the collar region. The number of gills is about fifty. In sections taken more to

the posterior end we find that the branchial canal increases in size, while the oesophagus correspondingly decreases.

(*b*) The *Genital Region* shows a similar arrangement of the musculature and the dorsal and ventral vessels. The gonads (fig. 7, *gon.*) are irregular

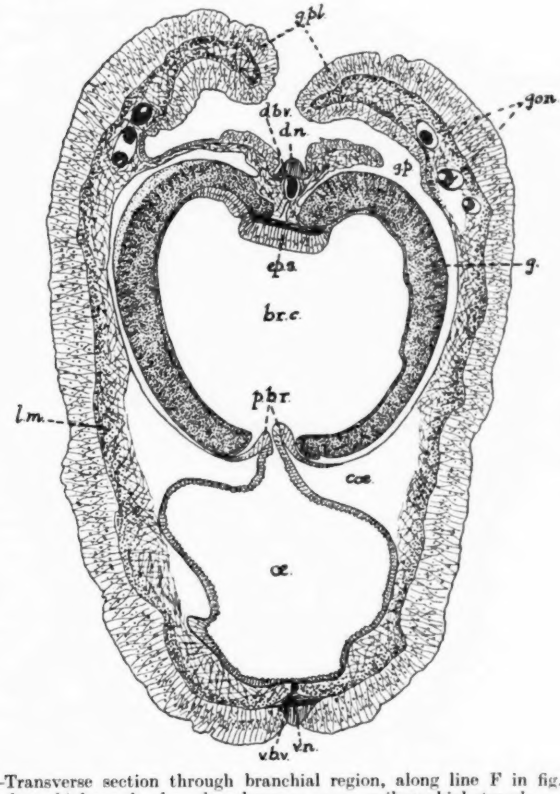

FIG. 7.—Transverse section through branchial region, along line F in fig. 1. × 30. *br.c.*, branchial canal; *d.n.*, dorsal nerve; *ep.s.*, epibranchial strand; *g.*, gill; *gon.*, gonads; *g.p.*, gill pore; *g.pl.*, genital pleura; *oe.*, oesophagus; *p.b.r.*, parabranchial ridges; *v.b.v.*, ventral blood-vessel; *v.n.*, ventral nerve.

in shape and the genital pore lies in the sublateral line where the lateral septum is attached to the epidermis.

(*c*) The *Abdominal Region* of this species does not show any marked variation from related species.

Vascular System.—The dorsal blood-vessel (figs. 5, 6, 7, *d.b.v.*) is well shown in sections of the branchio-genital region, occupying almost

the whole of the dorsal mesentery. In the collar region the dorsal vessel forms a wall separating the perihaemal spaces. Anterior to the perihaemal spaces the dorsal vessel opens into a larger space or lacuna situated over the notochord. The efferent proboscis vessels have already been described together with the proboscis glomerulus. They are continued into the collar, where dorsally a small vessel appears on either side between the inner longitudinal muscles of the collar and the peripharyngeal space. Ventrally there occur small scattered vessels which appear in most sections, but the capillary system was not observed. The ventral vessel is well developed, especially in the branchio-genital region (figs. 7, *v.b.v.*).

Reproduction.—Gilchrist (7) suspects that the two species of *Balanoglossus* occurring in False Bay, *B. capensis* and *B. proliferans*, might represent sexual and asexual forms of the same species. He cites the following differences occurring in the posterior part of the body, the anterior part being quite similar :—

B. capensis.	*B. proliferans.*
1. Hepatic caeca well shown.	No hepatic caeca visible externally or internally.
2. Abdominal region well marked off from the branchio-genital region.	Not clearly marked off.
3. Intestine filled with sand.	Not.
4. ...	Asexual reproduction takes place by successive fragmentations or proliferations at the extremity of the tail.
5. Occurs almost exclusively in winter.	Occurs in summer.

I wish to express my indebtedness to the Research Grant Board for the grant in aid of research by means of which the expenses in connection with the preparation of this paper were defrayed.

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FURTHER NOTES ON THE PHYSIOLOGY OF *TELOSCHISTIS FLAVICANS*.

By J. B. Cuthbert, M.A., Ph.D.

(With six Text-figures.)

In a previous account (Cuthbert, 1930) some preliminary experiments on *Teloschistis flavicans* were recorded. The present paper describes some further work in connection with the water relations and respiratory activities of this plant.

Water Relations.

In an attempt to analyse the water relations of a plant whose structure and habit precludes absorption from the substratum, the chief points for study have been the absorption of liquid on the surface and the surface relations to water vapour.

(a) *Water reaching the Plant as Liquid.*

When completely immersed in water, thoroughly dried portions of the plant were found to gain weight rapidly and soon attain a state of equilibrium; the increase in weight is about 186 per cent. on the dry condition. When the plant is first wetted water is absorbed by capillarity, the capillaries being the interstices between the cortical fungal hyphae. The fibrous nature of the cortex renders it eminently suitable for the accomplishment of this process.

In the previous communication it was shown that the rate of centripetal penetration of water from outside is very rapid, while longitudinal conduction takes place to a very limited extent.

(b) *Water Vapour Incident on the Surface.*

A series of experiments were described in the previous paper which showed that a portion of dried thallus, placed in a saturated atmosphere, underwent a rapid initial increase in weight, and that the increase gradually diminished in rate till, after fifty hours, none was detectable. In these experiments, however, it appears that the apparatus used is not entirely satisfactory; the friction of the pointer on the drum may be sufficient to prevent very small movements.

To obviate this and to obtain a record of fluctuations in weight a self-recording apparatus has been devised.

At first a "Tapping Recorder," as described by Bose, was set up, but this failed owing to a flaw in its design. In Bose's description of the apparatus (Motor Mechanism of Plants) he states:

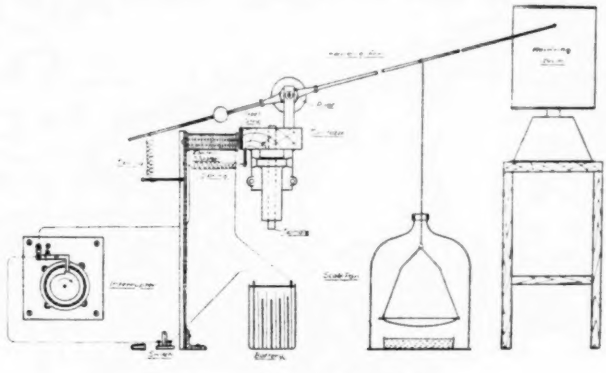
"The lever is hinged and a short piece of steel wire is attached to the recording lever in front of a small electro-magnet; the steel wire, periodically attracted at equal intervals by an intermittent electric current sent through the electro-magnet, causes the recording lever to make a series of dot-marks on the smoked plate . . ."

This arrangement was not found satisfactory, for, as the recording lever moved upwards or downwards, it moved from the region of maximum intensity of the magnetic field set up by the electro-magnet; so that when the contact was made, the lever instead of being pulled horizontally towards the drum, described an oblique motion giving a false value of the weight at any point. The further the recording lever moved from the horizontal position, the greater became this error. In order to overcome this difficulty, a new apparatus was designed. A substantial steel spindle about half an inch in diameter was fitted into a vertical bearing; a wooden turntable about 3 by 2 inches was securely fitted to the top of the spindle, and a narrow strip of steel was then screwed to the long edge of the turntable, parallel with the long axis and projecting about 2 inches beyond it. Two L-shaped pieces of metal were next screwed to the top of the turntable and carried the light horizontal spindle which formed the fulcrum of the recording lever. This apparatus was erected so that the end of the pointer was just clear of the smoked drum. An electro-magnet was then placed close to the steel edge of the turntable, and a light spiral spring attached to the turntable in such a way that it tended to pull the recording lever away from the drum. A check stop at the opposite corner of the turntable prevented the recorder from moving more than a quarter of an inch from the smoked drum. A light spiral spring was attached to the beam at a suitable distance behind the pivot, and a scale pan attached to the recording arm on the opposite side, in such a way that it could be readily detached from the beam, placed in a bell-jar, and again suspended from the beam.

When the electro-magnet was connected to a source of electric current and an automatic intermittent contact maker, driven by clockwork, was included in the circuit, the turntable was turned through a small angle, causing the recording lever to tap sharply against the smoked drum every time the circuit was closed. When the circuit was opened, the spiral spring pulled the recording lever out of contact with the drum. By this means, the pointer itself was not influenced by the electro-magnet, and

since the metal-edged turntable carrying the recording lever always remained in the same horizontal plane as the electro-magnet, there was no tendency to impart an oblique motion to the lever, as was inevitable with Bose's apparatus (fig. 1).

A weighed portion of dried thallus was placed in the scale pan, which was in a bell-jar over a dish of water. The contact-maker was then set to make and break the circuit once every hour, and the recording drum set



TAPPING RECORDER

FIG. 1.

in motion. Fluctuations in the weight of the thallus were recorded as a series of dot-marks on the smoked drum.

Records taken with this apparatus were confirmed by the method of successive weighing.

In the first curve taken with the apparatus, the material showed a rapid increase in weight for about forty hours, after which the rate of increase diminished until, about sixty hours later, the increase had reached a small and almost constant value, which was maintained to the end of the record, viz. nineteen days. (It was found impossible to take a record for more longer periods owing to growths of fungus on the lichen.) The latter portion of the curve, from about the fifth day, was invariably a straight line, showing a constant though small increase of weight.

It was found that the method of drying the lichen had considerable effect on the form of the subsequent curve. Portions of thalli of Teloschistes which had been in a desiccator for about a week at laboratory temperature gave a curve practically identical with that obtained from material which had been dried at temperatures not exceeding 60° C. Drying at higher temperatures, or alternatively, prolonged drying (about

twenty days) in a desiccator at laboratory temperature gave curves different from those resultant on the employment of less drastic drying methods.

The figure illustrates the effect of varying the method of drying on the form of the curves (fig. 2). The curves in the figure have been transposed from the original records for convenience of presentation. Curve A shows the rate of absorption of water-vapour into material which had been dried in a desiccator for four days at laboratory temperature. In B the lichen was dried for three days at a temperature of 60° C. In C the lichen was dried at laboratory temperature for nineteen days; while curve D was

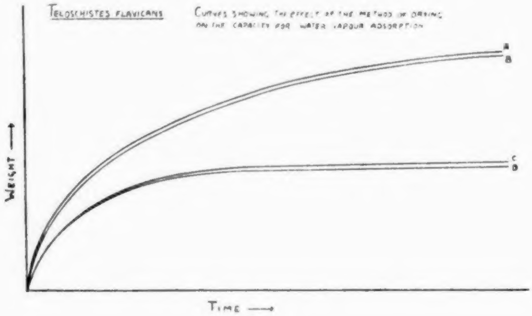


FIG. 2.

obtained from material which had been subjected to a temperature of 98° C.

From these curves it appears that the initial rate of absorption of water-vapour is independent of the method of drying the thallus. In the subsequent stages of the absorption the curves fall roughly into two groups. In the upper two curves, the rapid stage of absorption continues for a longer time than it does in the lower two. The rate then diminishes gradually, finally giving place to a slow but constant rate of increase of weight. In the lower two curves, the initial period of rapid absorption is not so prolonged, and ceases rather abruptly to give place to a constant rate of increase considerably slower than that indicated by the corresponding portion of the two upper curves. This seems to indicate that the rather drastic methods used in drying the material for curves C and D had considerably influenced the subsequent process of absorption of water-vapour.

Portions of fronds which had been subjected to these various methods of drying were then soaked in paraffin oil for a short time. Thin transverse sections of these softened fronds were then cut. Careful microscopic examination of these sections revealed no observable differences in the fungal hyphae. In the material, however, which had been subjected to

drastic drying methods, and particularly that which had been dried at 98° C., the gonidial cells had been killed. The cell walls were in many cases shrivelled up, and the plastids had broken down, liberating their pigments into the cells.

The increase in weight of thalli of Teloschistes when in an atmosphere of high humidity is due to the adsorption of molecules of water-vapour on to the thallus. Water-vapour from the atmosphere is adsorbed on to the surface of the hyphae of the cortex. The molecules of water-vapour may then condense to liquid in the inter-hyphal spaces, but more probably do so in the micropores of the hyphae themselves. This condensed water may move in the micropores by capillarity, and may ultimately be in a position to be influenced by the osmotic pressure exerted by the cell-sap, and so cross the semi-permeable membrane of the protoplasm into the vacuole.

If the adsorption curves figured are considered in the light of this explanation, the possibility of interpreting the two stages in the increase in weight becomes apparent. The initial steep portion common to all the curves corresponds to the rapid adsorption of water-vapour into the interstices between the hyphae, and on to the external surface of the hyphae inside the frond. The later "straight line" portion of the curves may possibly correspond to either (*a*) the transference of the condensed water-vapour in the micropores of the hyphal walls across the protoplasm into the vacuole (this view would explain the separation of the four curves into two groups, since if the severe desiccation undergone by the thalli of curves C and D had destroyed or impaired the efficacy of the protoplasm as a semi-permeable membrane, the cell solutions in the vacuole would not be able to exert an osmotic pressure as high as that exerted by cells with an undamaged membrane, so that the condensed water in the micropores would not be drawn into the cell cavity as rapidly or to so great an extent, resulting in a diminution in the rate of the whole process of adsorption, with a consequent diminution of the rate of increase of weight), or (*b*) it might correspond to the adsorption of the vapour into the micropores of the hyphae walls. The divergence of curves C and D is also explainable on this basis, if the drastic treatment in drying had compacted the walls of the hyphae sufficiently to reduce the area available for adsorption on the inner surfaces of the micropores, the rate of adsorption at this stage of the process would be diminished.

The most interesting outcome of these experiments on the adsorption of water-vapour into *Teloschistes flavicans*, at any rate from the point of view of usefulness to the plant, is the rapidity of the process in the case of very dry material, and the large increase in water-content which can be attained without necessity for the presence of liquid water as the source of supply.

The absence of any impervious surface in lichens is a factor which makes their existence in extremely dry situations possible.

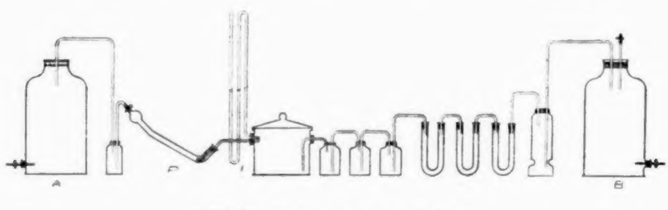
The importance of the utilisation of water-vapour adsorbed from the atmosphere to lichens in arid habitats may go a long way towards explaining the hardihood and drought-resisting powers of these plants.

Respiration.

It has been generally affirmed by lichenologists that the metabolic functions of lichens and notably those of assimilation and respiration bear some relation to the water-content of the plant. Lorrain Smith states that the addition of water to a lichen brings about an optimum condition of assimilatory and respiratory functions, after which further increase in the water-supply causes no further change. The object of the present investigation was to correlate the rate of respiration with the water-content of *Teloschistes flavicans* over as wide a range of water-contents as possible. With regard to the choice of apparatus for this task, preliminary experiments had proved the suitability of the Pettenkofer apparatus for determining the carbon-dioxide output of material with a water-content ranging from moderately low to complete saturation. A slightly modified form of this apparatus was consequently used for this purpose.

Pettenkofer Apparatus. (Fig. 3.)

The apparatus included a series of vessels for the complete elimination of carbon-dioxide from the air. These comprised a tower packed with



PETTENKOFER RESPIRATION APPARATUS

Fig. 3.

sticks of caustic potash, the base of which contained a strong solution of potash, into which the air inlet tube dipped, followed by three **U**-tubes, two packed with soda-lime and one containing fragments of caustic potash. The **U**-tubes were followed by three small wash-bottles in series. When a determination of the carbon-dioxide output of thoroughly dried material

was to be made these bottles contained concentrated sulphuric acid. In all other determinations they contained water. The respiration chamber used was a desiccator completely covered with opaque material. In "dry" determinations the lower part of the desiccator was filled with concentrated sulphuric acid. The inlet and outlet tubes into the respiration chamber were maintained as far apart as possible. A sensitive manometer containing thin lubricating oil indicated changes in pressure in the respiration chamber. On the outlet side of the respiration chamber a small wash-bottle was fitted, which contained concentrated sulphuric acid during "dry" determinations, and acted as a trap against the back-passage of water-vapour from the Pettenkofer tube. A U-tube placed at the other end of the Pettenkofer tube and filled with fragments of caustic potash prevented any entry of carbon-dioxide from the aspirator into the Pettenkofer tube.

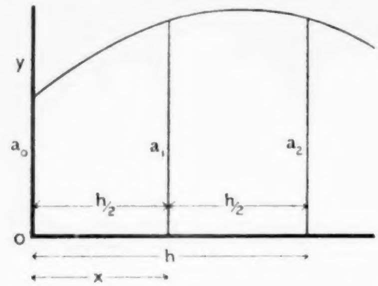
Every possible point of leakage was liberally coated with melted resin ointment, which on cooling forms a very effective air-tight seal. The lid of the desiccator was also sealed with resin ointment.

On account of the resistance to the passage of gas offered by the large number of wash-bottles and U-tubes in the circuit, it was found impossible to maintain a steady bubbling of gas through the Pettenkofer tube if a single aspirator was used. To overcome this difficulty two large aspirator bottles were utilised, one at each end of the apparatus. From the bottle A water was allowed to trickle slowly out while water was introduced into B. Adjustments of the rates of flow of water out of A and into B led to the maintenance of atmospheric pressure in the apparatus and a steady flow of bubbles through the Pettenkofer tube P.

In using the apparatus a current of air aspirated over the material for one hour before the Pettenkofer tube containing standard baryta water was introduced into the circuit. A steady stream of air was then aspirated through the apparatus for six hours, when the Pettenkofer tube was removed, and its contents poured into a small stoppered bottle, and allowed to settle overnight. Portions of the solution were drawn off and titrated against standard oxalic acid. At the conclusion of the experiment the lichen was removed from the respiration chamber, weighed, and then placed in a steam oven until thoroughly dry, and then reweighed.

In these experiments, and especially those of determinations of the carbon-dioxide output of thalli with a small water-content, some increase in weight due to the adsorption of water-vapour in the apparatus took place. From a knowledge of the weight of the thalli before and after the experiment, and also of the dry weight, the portion of the previously determined standard curve for the adsorption of water-vapour (increase on dry weight expressed as a quotient of the dry weight, and plotted against

time) corresponding to the period of the carbon-dioxide determination could be readily selected. The mean value for the weight (*i.e.* water-content) of the thallus over the experimental period was derived from this portion of the curve by means of the formula below:



Let the above figure represent a portion of the curve. Assume that the curve is of second degree form. The general equation is

$$y = A + B\frac{x}{h} + C\frac{x^2}{h^2}.$$

At

$$x = 0, \qquad A = a_0.$$

Put

$$x = \frac{h}{2}, \qquad a_1 = a_0 + \frac{B}{2} + \frac{C}{4} \quad . \quad . \quad . \quad . \quad . \quad (1)$$

Put

$$x = h, \qquad a_2 = a_0 + B + C \quad . \quad . \quad . \quad . \quad . \quad (2)$$

Solving (1) and (2) for B and C,

$$B = -3a_0 + 4a_1 - a_2,$$
$$C = \ \ 2a_0 - 4a_1 + 2a_2,$$

$$\text{Area} = \int_0^h y \,.\, dx = \int_0^h \left[A + B\frac{x}{h} + C\frac{x^2}{h^2} \right] dx$$

$$= \left[Ax + \frac{Bx^2}{2h} + \frac{Cx^3}{3h^2} \right]_0^h$$

$$= Ah + \frac{Bh}{2} + \frac{Ch}{3}$$

$$= h\left[a_0 + \frac{4a_1}{2} - \frac{3a_0}{2} - \frac{a_2}{2} + \frac{2a_0}{3} - \frac{4a_1}{3} + \frac{2a_2}{3} \right]$$

$$= \frac{h}{6}[a_0 + 4a_1 + a_2].$$

From this area division by the value of the abscissa gives the required mean value of the ordinate.

ERRATA.

Transactions, Vol. XXII., Part I.

Page 43, lines 17 to 25, *for* "Area = . . . 6·43 per cent." *read*

$$
\begin{aligned}
\text{Area} &= \frac{h}{6}(a_0 + 4a_1 + a_2) \\
&= \tfrac{76}{6}(111 + 4 \times 136 + 115) \\
&= 10260. \\
\therefore \text{ Required mean} &= \tfrac{10260}{76} \\
&= 135 \text{ divisions,}
\end{aligned}
$$

which is equivalent to a true value of 0·135 for increase in dry weight/dry weight.

From a previous experiment it is known that a value of 1·85 is equivalent to a percentage saturation of 100, so that the percentage saturation corresponding to a value of 0·135 for the increase in dry wt./dry wt. is 7·3 per cent.

The following, from an actual experiment, will serve to explain the application of this method.

Specimen E.

Placed in the respirometer chamber from natural conditions. The chamber saturated with water-vapour.

Weight at commencement	$=56\cdot7$	gr.
Dry weight	$=51\cdot0$	,,
Increase on dry wt./dry wt.	$=0\cdot111$.	

(This value is located on the curve, and the duration of the experiment is stepped off along the x axis. The values of h, a_0, a_1, and a_2 are determined by measurement.)

$$h = 76 \text{ divisions.}$$
$$a_0 = 111 \quad ,,$$
$$a_1 = 136 \quad ,,$$
$$a_2 = 155 \quad ,,$$

Substituting in the formula,

$$\text{Area} = \frac{h}{6}(a_0 + 4a_1 + a_2)$$

$$= \tfrac{76}{6}(111 + 4 \times 136 + 115)$$
$$= 1620.$$
$$\text{Required mean} = \tfrac{1620}{138}$$
$$= 0\cdot119.$$

From a previous experiment it is known that a value of 1·85 is equivalent to a percentage saturation of 100, so that the percentage saturation corresponding to a value of 0·119 for the increase in dry wt./dry wt. is 6·43 per cent.

Three portions of 10 c.c. of the clear baryta were titrated in a small conical flask with the standard solution of oxalic acid. With this method each titration was completed in some thirty seconds, so that the additional precaution of plugging the neck of the flask with cotton-wool was hardly necessary.

A complete experiment was then performed with an empty respiration chamber. This is a necessary precaution, for the titre of baryta water invariably changes a little after prolonged bubbling of even carbon-dioxide free air through it.

In order to reduce the results to a quantitative basis the titration values for the various experiments were subtracted from the value determined with an empty respiration chamber. The differences, in c.c. of standard oxalic acid solution, enabled the amounts of carbon-dioxide emitted by the lichen during the course of the experiment to be derived.

The results of six determinations of the carbon-dioxide output of *Teloschistes flavicans* over a wide range of water-content are summarised in the table.

TELOSCHISTES FLAVICANS.

Variation of Rate of Respiration with Water-content.

(Pettenkofer Apparatus.)

Specimen	1.	2.	3.	4.	5.	6.
Experimental conditions.	Dried at 98° C.	As 1, then exposed to water-vapour.	Dried at laboratory temperature.	Exposed to water-vapour from natural conditions.	Immersed in water from natural conditions.	As 5.
Dry weight	35·1 gr.	35·1 gr.	51·0 gr.	50·0 gr.	14·8 gr.	15·8 gr.
Per cent. satu.	0%	5%	6%	18%	92%	100%
$Ba(OH)_2$ titre	0·40 c.c.	0·40 c.c.	1·20 c.c.	1·05 c.c.	6·45 c.c.	1·95 c.c.
Titre per gr. dry weight per hour.	0·0019 c.c.	0·0019 c.c.	0·0039 c.c.	0·0043 c.c.	0·0727 c.c.	0·0206 c.c.
C.c. CO_2 per gr. dry wt. per hour at N.T.P.	0·0133 c.c.	0·0133 c.c.	0·0278 c.c.	0·0307 c.c.	0·5181 c.c.	0·1470 c.c.

In specimens (1) and (2) the rate of emission of carbon-dioxide per gram of dry weight per hour, expressed at N.T.P., is identical. In both cases the thalli were dried at a temperature of 98° C., and although Specimen 2 had been allowed to adsorb a considerable amount of water-vapour its carbon-dioxide output remained the same as that of Specimen 1, in which case the determination had been carried out without the presence of the minutest traces of water-vapour, since the wash-bottles and the lower portion of the respiration chamber had contained concentrated sulphuric acid in this case. Further determinations established the constancy of this very slow carbon-dioxide output of thalli which had been dried at high temperatures.

This fact is not readily susceptible of explanation, but it seems probable that in both cases the lichen had been killed by exposure to an excessively high temperature, and that the emission of carbon-dioxide was not any manifestation of the activity of living protoplasm, but was resultant on

the initiation of some post-mortem phenomenon, the rate of which was not altered by the adsorption of water-vapour by the thallus.

Support to this suggestion is given by a consideration of the water-vapour adsorption curves on a previous page, where it will be seen that the curve for material dried at 98° C. is an anomalous one. The amount of adsorbed water-vapour being considerably less than that of thalli dried for a short time at 60° C. or less.

Consideration of this table (columns 3–6) shows that from 6 per cent. saturation the rate of evolution of carbon-dioxide rises rapidly with increase of water-content up to 92 per cent. saturation, but falls off somewhat at complete (100 per cent.) saturation.

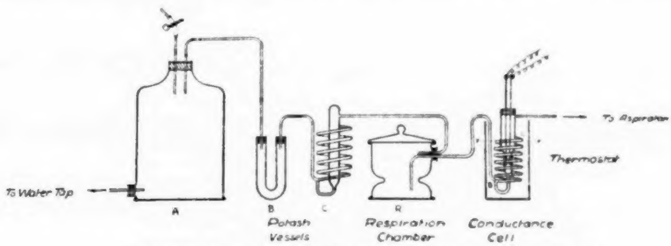
The percentage saturation (92 per cent.) corresponding to the highest rate of carbon-dioxide output in these experiments is probably not the true optimum value. While insufficient to permit the plotting of an accurate curve of the variation of respiratory activity with variation in the water-content, these experiments are sufficient to indicate the general trend of the curve and show that it approximates in form to the type of curve arrived at by Jumelle and other workers on this subject.

For more precise determinations, and especially for those of plants with very small water-contents and consequently with a very minute output of carbon-dioxide, this method was not suitable, and a more sensitive apparatus was employed.

An Electrical Conductivity Apparatus.

An electrical conductivity method for determining the rate of respiration of *Teloschistes flavicans* under conditions of extremely low water-content was employed.

The apparatus used for this purpose was based largely on a description



CARBON DIOXIDE RECORDER – Electrical Conductivity Method –

Fig. 4.

of a carbon-dioxide recorder devised by Gordon and Lehmann (Journ. Sci. Instr., vol. v, 1928, pp. 123–126). Some modification of the apparatus,

and especially of the electrical portion of it, was necessary in order to attain a degree of accuracy suitable for the present investigation. The following argument of the theory of the instrument is quoted from Gordon and Lehmann:—

"The instrument is based on the variation in the equilibrium concentration of the carbonate and bicarbonate salts of the alkaline earths, produced by an alteration in the partial pressure of carbon-dioxide in contact with the solution. The solubility of the carbonate is very much less than that of the bicarbonate, so that the conductivity of the solution is determined by the bicarbonate concentration, which in turn is dependent upon the carbon-dioxide concentration of the gas in contact with the solution. Thus the gaseous carbon-dioxide concentration may be determined by measuring the electrolytic conductance of the solution. Of the various alkaline earths barium has proved most sensitive to small fluctuations in carbon-dioxide concentration.

"The sensitivity increases with increasing atomic weight, magnesium being very insensitive.

"The relationship between the electrolytic conductance and the carbon-dioxide concentration may be deduced from a simple application of the law of mass action. Referring to the equation

$$BaCO_3 + H_2CO_3 \rightleftharpoons Ba(HCO_3)_2,$$

it is evident that, given an excess of solid barium carbonate, the concentration of dissolved barium carbonate will be constant at its saturation value, and the concentration of barium bicarbonate will be proportional to the concentration of carbonic acid, and hence to the carbon-dioxide partial pressure of the gas in contact with the solution.

"Applying the law of mass action to the reaction

$$Ba(HCO_3)_2 \rightleftharpoons Ba^{++} + 2HCO_3^-,$$

we have

$$\frac{C_1}{C_2C_3^2} = K,$$

where C_1, C_2, and C_3 are the concentrations of undissociated barium bicarbonate, barium ion, and bicarbonate ion respectively; and K is a constant. The conductivity of the solution is proportional to C_2 and obviously $C_3 = 2C_2$. Therefore $C_1 = K'C_2^3$, where $K' = 4K$, and the bicarbonate concentration is proportional to the cube of the conductivity of the solution.

"Since the bicarbonate concentration is directly proportional to the carbon dioxide concentration in the gas in contact with the solution, it follows that

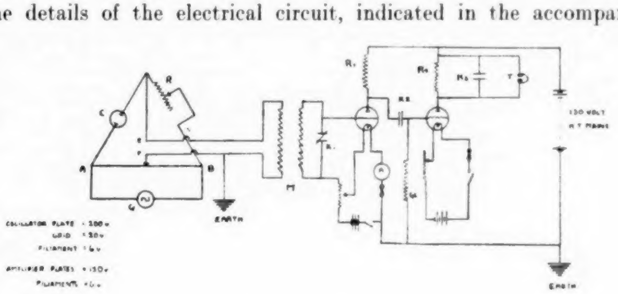
$$P = AI^3,$$

where P is the percentage of carbon-dioxide in the gas, I is the current through the electrolytic cell, and A is a calibration constant depending on the geometrical arrangement of the electrodes, the chemical equilibrium cœfficients, and on the potential difference applied to the electrodes."

The design of the apparatus is indicated in the accompanying figure (fig. 4). It was filled with a saturated solution of barium carbonate to the level FF. A considerable excess of solid barium carbonate was present. The gas entered A and was thoroughly scrubbed with the liquor in the spiral lift BC. The conductance of the cell was measured at regular intervals by a Kohlrausch Bridge, with two-step thermionic amplification.

The usual Kohlrausch Bridge method of measuring the conductivity of the solution in the cell did not permit of the attainment of the high degree of accuracy desired for the investigation, but by the adoption of a thermionic oscillator as a source of alternating current, and the utilisation of two-step thermionic amplification, the requisite standard of accuracy was ultimately achieved.

The details of the electrical circuit, indicated in the accompanying



WIRING DIAGRAM OF KOHLRAUSCH BRIDGE WITH TWO STEP AMPLIFICATION

FIG. 5.

wiring diagram, are as follows: The thermionic oscillator G was used to supply alternating current to the metre bridge AB. In the arm of the bridge net opposite to C a low induction variable resistance R, of dialled box type, was inserted.

From the common terminal of C and R a connection was made through the primary of a variable induction coil, and thence back to the sliding contact F on the bridge wire. This line was earthed as shown.

The secondary of the coil was wound on a sliding core, so that the coupling was variable over a wide range.

The A.C. oscillations in the primary induced a varying potential in the secondary, which was impressed on the grid of the first amplifier valve as shown; the secondary being shunted by a variable condenser K_1.

Two valves connected by resistance capacity coupling were used to achieve greater amplification than could be obtained from one alone. Thus the plate of the first valve was connected to the grid of the second, through a condenser K2. The grid was also connected to the earthed negative

pole of the 130-volt plate battery through a 2-megohm grid leak resistance GL, to prevent the accumulation of an excess negative charge on the grid.

High resistance R1 and R2 (about 0·1 megohm) were inserted in the respective plate circuits to give a large available potential drop. A pair of low-resistance headphones shunted by a condenser K3 was put across R2 at the output of the second valve.

The resistance R was adjusted to give the point of balance about the middle of the bridge wire, to get the maximum possible sensitivity.

The coupling of M was adjusted until the sound in the headphones was at a minimum before making contact with F. This gave the most narrow limits to the range of minimum sound on making contact.

The point of balance was definable within half a millimetre of bridge wire. The valves used were old B.B.C. models (type L.S.3), and were worked on 0·65-amp. filament current from 6-volt accumulators.

The disposition of the respirometer apparatus is illustrated in the accompanying sketch.

In use water was slowly introduced into the large vessel A, and the filter pump at the outlet tube of the conductance cell set in operation. Thus the air contained in A was drawn over the fragments of potash in the U-tube B, through the scrubbing device C containing potash solution, and into the respiration chamber R. From R the gas passed into the conductance cell, where, by slow bubbling through the spiral scrubber, its carbon-dioxide content was absorbed by the carbonate solution. The change in conductivity of the solution was detected with the electrical apparatus already described.

Adjustment of the water-taps, in conjunction with observation of the manometer, enabled a steady flow of gas at atmospheric pressure to be maintained.

The determinations give the carbon-dioxide output in terms of millimetres of deflection along the bridge wire, and are thus only comparative results. It was therefore thought advisable to calibrate the apparatus and thus to ascertain the exact quantity of carbon-dioxide corresponding to unit deflection on the bridge wire. The method employed was as follows: The respiration chamber (see figure of apparatus) was removed and its place taken by a small stoppered bottle fitted with four tubes. Of these one formed an inlet into the bottle from the vessels B, C, and the other formed the outlet into the conductance cell. The third tube led to a dropping funnel containing dilute sulphuric acid, while the fourth tube was attached to a sensitive manometer containing thin lubricating oil.

To perform a calibration experiment a very small quantity of pure sodium carbonate (usually about 0·02 gram) was very accurately weighed and carefully placed in the bottle replacing the respiration chamber, which

was then tightly stoppered. A slow current of carbon-dioxide free air was then passed through the apparatus until the "null point" remained constant on the bridge wire. The dilute acid was then introduced a drop at a time, until all the sodium carbonate had disappeared, while the circulation was maintained until the "null point" had again become constant.

As a result of a number of calibration experiments it was found that the total deflection corresponding to the liberation of carbon-dioxide from 0·02 gram of pure sodium carbonate gave a mean value of 38 millimetres of bridge wire. By calculation from the appropriate equations it is found that 0·02 gram of sodium carbonate will liberate 0·33 c.c. of carbon-dioxide at N.T.P.

It therefore follows that a deflection of one millimetre on the bridge corresponds to the liberation of 0·008 c.c. of carbon-dioxide measured at N.T.P.

The following results give particulars of determinations of the rate of carbon-dioxide output (expressed in terms of millimetres of deflection on the bridge wire) of a series of thalli of *Teloschistes flavicans* with water-contents ranging from 9·1 per cent. to 0·4 per cent. of total saturation. The results are further summarised in a single table for convenience, and the accompanying graph is the result of plotting the carbon-dioxide output (mean deflection on bridge wire per hour) against the percentage saturation of the thallus.

Readings were taken at approximately one-hour intervals over a period of at least three hours for each determination. At the conclusion of each determination the thallus was weighed (in order to permit of the calculation of the mean weight during the course of the experiment, as explained previously), thoroughly dried, and again weighed.

A series of determinations performed with this apparatus afforded ample proof of the accuracy of the method. In these determinations portions of thallus were brought to a suitable water-content by drying in a desiccator, weighed, and placed in the respiration chamber. A slow, steady current of air was then passed through the apparatus, and readings of the conductivity of the solution in the conductance cell were taken at intervals. The volume of air passed through the apparatus was determined by measuring the rise of the water in the jar A, which was of 20 litres capacity.

The electrical conductivity apparatus described in the preceding pages has certain very definite advantages over the more usual forms of apparatus commonly employed in the gas analyses incidental to many researches in plant and animal physiology. The degree of accuracy of this apparatus for the measurement of small quantities of carbon-dioxide is very much higher than that of, say, the Bonnier and Mangin apparatus. With the latter apparatus it is theoretically possible to determine, even allowing for no

experimental error at all, the carbon-dioxide content of an atmosphere containing one part of carbon-dioxide per thousand. In actual practice, however, this standard of accuracy is quite incapable of attainment. With the electrical conductivity apparatus described, one part of carbon-dioxide per two hundred thousand can readily be determined within the limits of experimental error.

A particular example will make this difference clearer. With a piece of experimental material emitting carbon-dioxide at the rate of, say, 0·02 c.c. per hour, accurate determinations can be made with the conductivity apparatus every half-hour, after the removal of all atmospheric carbon-dioxide from the respiration chamber. To use the Bonnier and Mangin apparatus for the same determination the experimental material would have to be left in a closed chamber for several days before the composition of the gas had altered sufficiently to make a single determination possible.

The apparatus as described is by no means in its most perfected state. Further experiments have indicated that the sensitivity of the electrical portion of the apparatus could be considerably improved by the use of micrometer controls and by suitable screening of the valves. The design of the conductance cell itself, arrangement and size of the electrodes, could also be modified to give the maximum accuracy for the carbon-dioxide output involved in any particular investigation.

For investigations where the quantities of carbon-dioxide are not excessively minute, the electrical portion of the apparatus can be considerably simplified by discarding the amplifying circuit used in the present investigation, and using the simpler Kohlrausch Bridge circuit.

Teloschistes flavicans.

Variation in Respiration Rate with Water-content.

Specimen 1.

Mean experimental weight . . .	25·05 gr.
Dry weight	21·40 ,,
Increase on dry wt./dry wt. . .	0·170 ,,
Percentage saturation . . .	9·1 per cent.

Time.	Differences.	Readings.	Differences.	Differences per hour.
2.30	..	53·4		
3.30	60 min.	53·1	0·3 mm.	0·3 mm.
4.50	80 ,,	52·7	0·4 ,,	0·3 ,,
5.25	35 ,,	52·5	0·2 ,,	0·34 ,,
6.10	45 ,,	52·3	0·2 ,,	0·27 ,,

Page 51, line	1,	*for*	"specimen 2"	*read*	"specimen 3."
,, ,, ,,	5,	,,	"4·1 per cent."	,,	"3·7 per cent."
,, ,, ,,	11,	,,	"specimen 3"	,,	"specimen 4."
,, ,, ,,	12,	,,	"22·50 gr."	,,	"23·50 gr."
,, ,, ,,	15,	,,	"3·7 per cent."	,,	"0·4 per cent."
,, ,, ,,	21,	,,	"specimen 4"	,,	"specimen 2."
,, ,, ,,	25,	,,	"0·4 per cent."	,,	"4·1 per cent."

In all Tables in Columns 4 and 5, *for* "mm." *read* "cm."

Specimen 2.

Mean experimental weight . .	24·92 gr.
Dry weight	23·31 ,,
Increase on dry wt./dry wt. . .	0·069 ,,
Percentage saturation . . .	4·1 per cent.

Time.	Differences.	Readings.	Differences.	Differences per hour.
2.40	..	53·3		
3.40	60 min.	53·25	0·05 mm.	0·05 mm.
5.0	80 ,,	53·1	0·15 ,,	0·11 ,,
6.0	60 ,,	53·0	0·1 ,,	0·10 ,,

Specimen 3.

Mean experimental weight . .	22·50 gr.
Dry weight	23·31 ,,
Increase on dry wt./dry wt. . .	0·008 ,,
Percentage saturation . . .	3·7 per cent.

Time.	Differences.	Readings.	Differences.	Differences per hour.
1.45	.. .	53·86		
2.45	60 min.	53·77	0·09 mm.	0·09 mm.
3.45	60 ,,	53·73	0·04 ,,	0·04 ,,
4.45	60 ,,	53·68	0·05 ,,	0·05 ,,

Specimen 4.

Mean experimental weight . .	25·09 gr.
Dry weight	23·31 ,,
Increase on dry wt./dry wt. . .	0·076 ,,
Percentage saturation . . .	0·4 per cent.

Time.	Differences.	Readings.	Differences.	Differences per hour.
2.0	..	53·2		
3.20	80 min.	53·0	0·2 mm.	0·15 mm.
4.40	80 ,,	52·8	0·2 ,,	0·15 ,,
5.42	62 ,,	52·6	0·2 ,,	0·19 ,,
6.40	58 ,,	52·5	0·1 ,,	0·10 ,,

Summary of Results.

No.	Per cent. saturation.	Dry weight.	Experimental weight.	Increase on dry weight ÷ dry weight.	Per hour mean deflection.	c.c. CO_2 per gr. dry weight per hour.
1	9·1	21·40	25·05	0·170	3·0 mm.	0·044
2	4·1	23·31	25·09	0·076	1·5 ,,	0·022
3	3·7	23·31	24·92	0·069	0·8 ,,	0·012
4	0·4	23·31	23·50	0·008	0·4 ,,	0·006

It will be noticed that the curve is roughly a straight line—*i.e.* that between 0·4 per cent. and 9·1 per cent. saturation the rate of respiration of *Teloschistes flavicans* is a linear function of the water-content. This is an expected result, and it is further probable that the respiratory activity of the lichen persists as a linear function of the water-content for saturation values considerably higher than 10 per cent. before the slowing off of the rate of increase of the respiration rate is initiated prior to the attainment of the optimum rate (fig. 6).

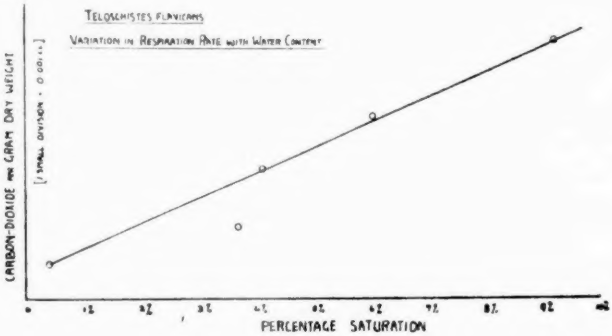


Fig. 6.

One is forced to conclude from these results that *Teloschistes flavicans* is alive and respiring with a water-content of only 0·4 per cent. of total saturation: for the fact that the rate of emission of carbon-dioxide rises steadily from 0·4 per cent. saturation through 3·7 per cent. and 4·1 per cent. to 9·1 per cent. saturation leaves no other alternative. In support of this it might be added that microscopic examination of the above thalli showed that the gonidial cells were still green and apparently not collapsed. The drying of the thalli for these experiments was attained by leaving the

thalli for appropriate periods in a desiccator, but in no case were they left in the desiccator for more than a few days.

Additional evidence of the behaviour of lichens after drying is afforded by a consideration of the water-vapour adsorption curves given on a previous page.

In curve A (fig. 2), in which the material had been dried in a desiccator at laboratory temperature for four days, the thallus was certainly alive as the above experiments show. In curve B, which approximates very closely to the first curve, and which corresponds to drying for a short period (three days) at 60° C., it is extremely probable that the thallus was also alive. Although the close correspondence of these two curves almost renders this supposition a certainty, it can only be definitely confirmed by respiration determinations of thalli under similar conditions.

In the lower two curves, which are very sharply differentiated from the other curves, it is probable that in both cases the thallus had been killed. Although this fact has only been definitely proved by respiration experiments for the curve of material dried at 98° C., the close conformation of curve C (that of *prolonged* drying at laboratory temperature) to this curve seems to indicate that in both cases the thalli had been killed by the drastic drying methods employed.

From a consideration of these experiments on the rate of adsorption of water-vapour into, and the rate of emission of carbon-dioxide from, thalli of *Teloschistes flavicans* which had been dried for different periods at various temperatures, the following conclusions have been made.

(1) Thalli of *Teloschistes flavicans* are killed by prolonged (19 days) drying at laboratory temperature.

(2) Thalli are killed after several hours' exposure to a temperature of 98° C. Such thalli exhibit a slow but constant post-mortem emission of carbon-dioxide, which is not augmented by increasing the water-content. This fact is at present unexplained.

(3) Thalli of *Teloschistes flavicans* can survive after several (3) days' drying at temperatures up to 60° C.

(4) Thalli can survive after several (3) days' drying at laboratory temperatures.

When these conclusions are considered in conjunction with observations of the habitats of *Teloschistes flavicans*, it appears that even under the most adverse conditions extant in the Cape Peninsula, the lichen is living well within its powers of resistance. It is very improbable that even at the dryest season of the year the water-content of thalli of *Teloschistes flavicans* ever falls below 10 per cent. of complete saturation, while the air temperature at any rate never approaches 60° C. It would be a very difficult task to measure experimentally the actual internal temperature

of fronds of the lichen, but in any case this probably never approaches 60° C. even on the hottest summer day, for the finely divided nature of the thallus must ensure fairly efficient radiation of heat.

With regard to the actual mechanism of drought resistance no definite conclusions can be drawn. It has been shown that Teloschistes can survive after exposure to fairly high temperatures, and also that the thalli are still alive with a water-content as low as 0·4 per cent. of complete saturation, but the reasons for this hardihood are very uncertain.

In view of the fact that lichens have no impervious covering or adaptation for internal water storage, it seems likely that the explanation of their mechanism of drought resistance should be sought for in the anatomical arrangement, physical nature, and chemical composition of both the cell walls and cell sap of their constituent cells rather than in physiological experimentation.

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THE DISCOVERY OF A STONE AGE MANGANESE MINE AT CHOWA, NORTHERN RHODESIA.

By Raymond A. Dart,

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(With Plates I–III and three Text-figures.)

TABLE OF CONTENTS.

1. Introduction.

Recently (1931), in company with Signor Nino del Grande, I published an account of the ancient iron-smelting cavern discovered by the Italian Scientific Expedition at Mumbwa in Northern Rhodesia. In that publication we wrote about "coarse and grotesque implements of semi-*coup-de-poing* type that are found in great quantity at the open site of manufacture of palaeolithic implements in manganese (psilomelane) at the Chowa manganese deposit, 8 miles from Broken Hill," *i.e.* 150 miles N.E. of Mumbwa.

At that time, as members of this Trans-African Expedition, we had imagined we merely stood in the presence of a previously unrecorded material utilised by primitive man for fashioning palaeoliths. We recognised that, if this were so, the site was unique because our palaeolithic predecessors had mined to a considerable depth in order to secure the material for making the palaeoliths. Neolithic mines had been heard of before, but palaeolithic mines never. Subsequently, however, the conception that the mining was done to make palaeoliths proved untenable. These psilomelane palaeoliths were not the products of the mine but the tools used for mining. By means of them the native psilomelane had

yielded up a manganese product of still greater purity, namely, pyrolusite or the crystalline sesquioxide of manganese. Some such internal soft or crystalline oxide of manganese (or both) had formed the central object of search in this mine.

The first text-figure is a sketch-plan illustrating the Chowa manganese claims of the Rhodesia Broken Hill Development Company. These claims

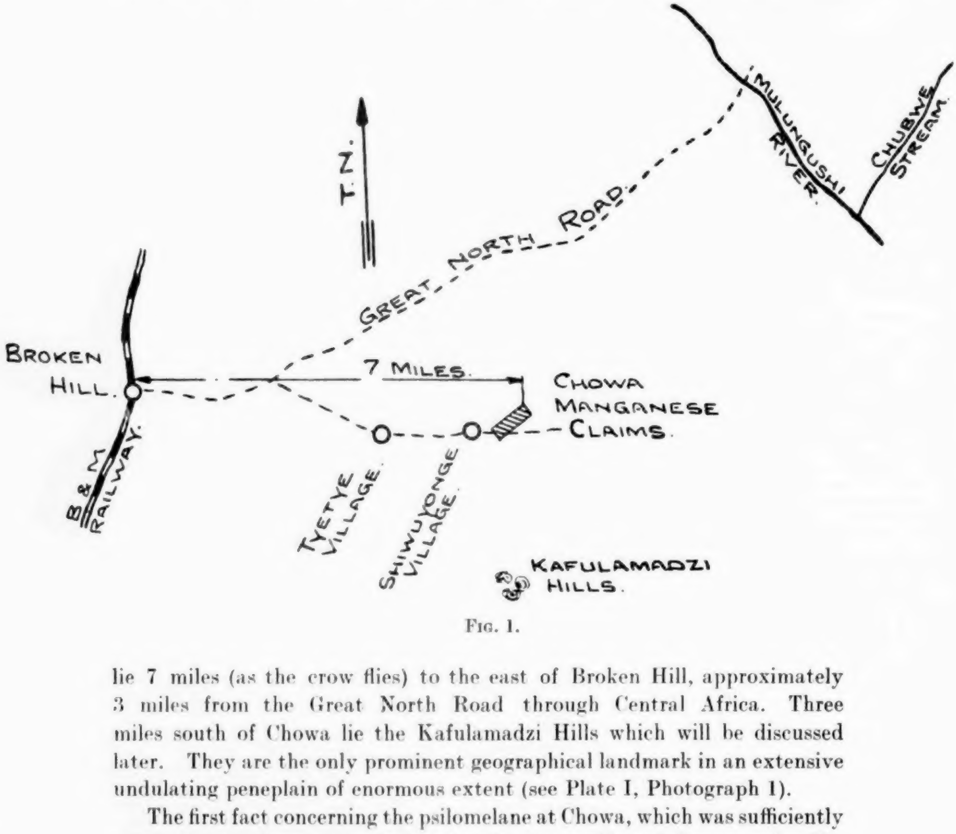

Fig. 1.

lie 7 miles (as the crow flies) to the east of Broken Hill, approximately 3 miles from the Great North Road through Central Africa. Three miles south of Chowa lie the Kafulamadzi Hills which will be discussed later. They are the only prominent geographical landmark in an extensive undulating peneplain of enormous extent (see Plate I, Photograph 1).

The first fact concerning the psilomelane at Chowa, which was sufficiently unusual to excite comment shortly after its accidental discovery by Mr. Frederick Bush six or seven years ago, was the minute and fragmentary nature of the rocky outcrop. Psilomelane is so much more resistant to weathering, in comparison with the other stony materials in the neighbourhood, that an extensive deposit (such as this proved later to be) should have constituted an obtrusive local topographical feature on the crest of

the Chowa ridge; but, on the contrary, it appeared merely as a couple of inconspicuous "stringers" some few inches high emerging in two restricted sites amidst the stubble.

Some time after the Mining Company had bought the claims, Mr. Bush was placed in charge of their development and became impressed with further curious characters of the deposit which he discusses in the following report made by him:—

The deposits of manganese at Chowa are approximately 300 yards long by about 40 yards wide, as discovered up to the present time. There are several lodes or lenses, only two of these lodes came to the surface and were about 6 inches above ground level in very few places. On all the lodes of manganese discovered up to the present, excavations have been carried down on them, varying in depth from 4 feet in the hard "clinker laterite" down to 15 feet in the softer formation. In all these excavations of loose soil, it was quite easy to go down with a pick and shovel to the depths mentioned, but in all formation that had not been excavated previously, it was necessary to blast in most places.

The foot and hanging walls can be plainly seen, and the excavations are all now filled quite up to the surface level, with black vegetation soil, quite a different soil from the matrix formation in which the manganese occurs. The distinct break in the formation can be plainly seen, right down on to where the excavation ends on top of the manganese (see fig. 3). All these excavations were filled up with loose soil to the surface, which contained a large quantity of manganese rubble varying in size from 3-inch to 4-inch pieces down to ½-inch. It could plainly be seen that this rubble had been artificially broken. In this rubble there were a lot of pieces, which had been roughly shaped by chipping. These excavations have been done on all the manganese lodes discovered up to the present (see Plate II, Photograph 2).

There must have been a good number of persons working on this manganese, and for a long time, by the very large amount of work done and the immense quantity of broken manganese discovered up to the present.

Some large round pieces of manganese up to 8 inches in diameter have been found, and some much larger pieces, which could be plainly seen, had been used for breaking manganese on.

I have been working on this manganese deposit for several years, ever since work commenced on it in 1927, and have never found a piece of bone, wood, carbonised charcoal, or native cooking-pots up to the present, although I have kept a constant look out for them, only the rough pieces of manganese and quartz, schist, and sandstone, some of which are quite different from the formation in which they have been found and must have been taken there by some persons.

There were no obvious signs, on the ground surface either by mounds, stones, rocks, or indentations on the ground, to show that any work had ever been done there, only here and there small quantities of very small pieces of weathered manganese could be seen on the surface of the ground in the grass.

The relationship of the area hitherto discovered to have been worked by the ancients to the manganese claims reserved by the Broken Hill Development Company is seen in fig. 2.

In certain places on close inspection the general ground surface is,

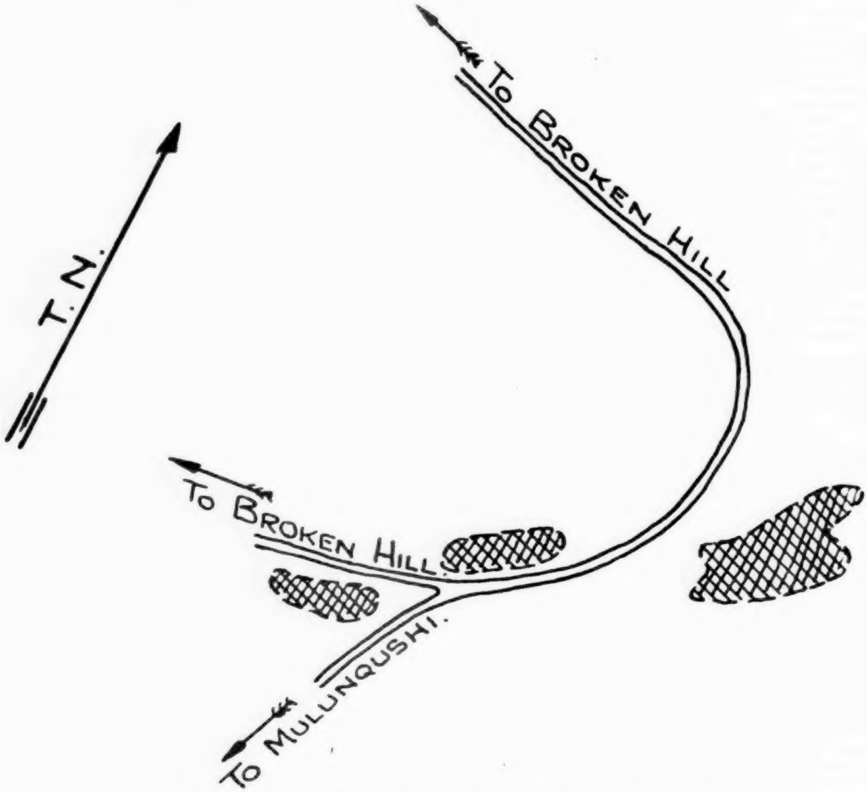

Fig. 2.—Plan of manganese claims. Scale: 1″ = 200 feet. Shaded areas indicate approximate locations in which old workings have been uncovered.

however, seen to be slightly depressed (see fig. 3). When trenches are dug across these in order to lay bare the manganese lode found at depth, the more darkly tinted surface layer of "vegetation soil" (which elsewhere varies from a foot to 2 feet in thickness) continues downwards along certain fixed tracts to a depth of 5 or even 15 feet. When these "vegetation soil" tracts are excavated they form—as our diagram shows—typical

open-mining trenches 18 inches to 2 feet in width (with sloping hanging walls and foot walls) which terminate abruptly below on the solid manganese lode. The "filling" of these great trenches, other than soil, is composed, as Mr. Bush pointed out, of flakes, lumps and blocks of psilomelane, quartzite, schist, ironstone, and other materials (see Plate II, Photographs 1 and 2). It is rubble that has been tossed into the trenches after the lode (which must originally have extended to the surface or beyond it either as a solid block or in the form of "stringers") had been exploited down to that level. Here I may note in parenthesis that the maximum trench depth of 15 feet corresponds roughly to the subsoil water-level in the dry season, beyond which mining operations are hampered by the presence of seepage water in that part of Northern Rhodesia.

The Broken Hill Mine from 1927 to 1931 (*i.e.* four years) was using manganese at the rate of 15–20 tons per week. The major portion of the psilomelane used was this rubble sieved from the old workings. The modern mine has therefore consumed between 3000 and 4000 tons of the refuse of the ancients.

As under the operation of purely natural forces, the psilomelane ought to-day to be a prominent outcrop, unnatural interference on the part of man is responsible for destroying the original outcrop. The paltry "stringers" of the black outcrop were merely portions that had been overlooked by the primitive miners. These remnants escaped detection at that remote time simply because they then lay below the ordinary ground surface. They were exposed afterwards as a result of the general soil denudation that occurred in the intervening period, which must have removed a foot or more of the ridge as hill wash.

That conclusion is based not only on our knowledge that soil erodes fairly rapidly to-day in Southern Africa, but also on two further inferences. The first is that our ancient mining brethren would not have been so foolish as to fail in working a promising surface outcrop when their excavations nearby were being carried to a depth of 15 feet. The second inference is that their mining was accompanied by superstition or secrecy, or by both. For, when they had dug these ramifying trenches, smashed the rock to fragments and recovered the more precious material, they did not dump the mining refuse indiscriminately about the neighbourhood, but by the expenditure of untold energy (since they had no shovels) they heaved it into the original excavations.

They did this seemingly useless work with such thoroughness that no external trace has hitherto been discovered thereabouts of their activities. The directors of the enterprise were powerfully induced either by religious feeling or by commercial secrecy to fill their open shafts and trenches with that broken-down matrix and waste material. They would have defeated

their purpose had they left exposed these modern indicators of the psilomelane below. The passage of time and the caprice of nature exposed to modern industry the evidences of their handiwork.

The object of these remarks is to show that the soil erosion, however rapid (which exposed these previously hidden "stringers" of the outcrop),

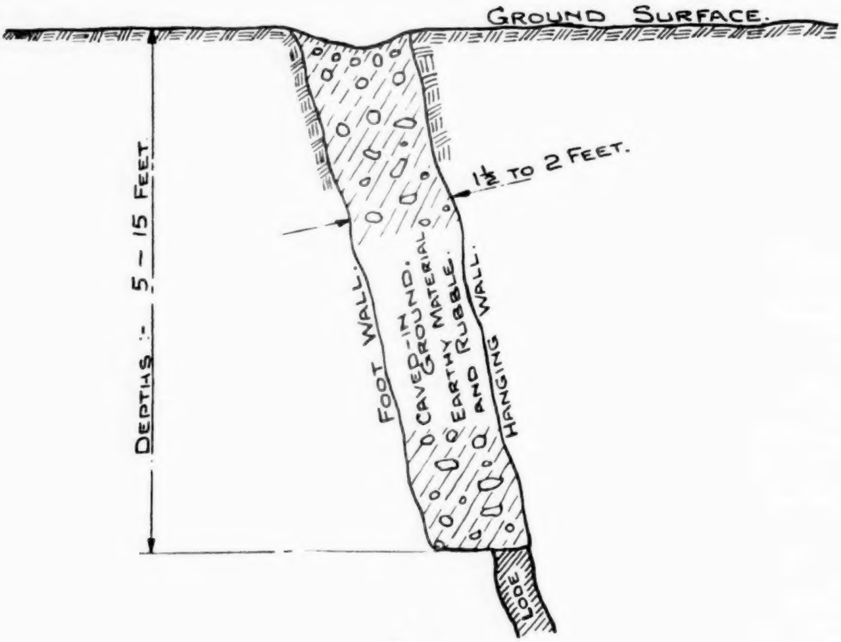

FIG. 3.

supplies us with collateral evidence of the considerable lapse of time since this secretive mining was carried out. It is to be reckoned in thousands of years.

2. The Contents of the Rubble at Chowa and the Rock-shelters of Kafulamadzi.

The total absence of any local clue concerning the site of habitation of the mining community induced us to search for them in the commanding quartzitic hills of Kafulamadzi 3 miles away. This laborious work was carried out chiefly by Signor Nino del Grande who ultimately located half a dozen rock-shelters in the hills (see Plate I, Photograph 2). None of these shelters were deep enough to afford much protection from the

elements, and their floors were usually so restricted that there was very little opportunity for the building up upon the acutely sloping hillsides—where the detritus was scattered—of any great quantity of floor deposit. The deepest deposits found varied from 9 to 18 inches in thickness and presented no real stratification.

The deposits therefore gave no precise conception of the actual time that has elapsed since they were laid down. But this series of excavations demonstrated the presence of a representative series of hammers, flakes, and *coup-de-poings* of psilomelane of the Chowa type in several of the shelters. This psilomelane could not have come from the quartzite hills themselves and must have been transported thither from Chowa when the mining was in progress. Our supposition was therefore completely ratified that the people who mined at Chowa had occupied simultaneously the Kafulamadzi hills. The two sites were to be regarded as a single unit; though the psilomelane fragments must have been used for domestic rather than mining purposes on Kafulamadzi.

In addition, in these shelters alongside the psilomelane and scattered over the hillsides was an infinitude of white and crystalline quartz flakes, contrasting sharply in colour with the duller quartzite mass of the hills themselves and demonstrating complete familiarity with Late Stone Age technique on the part of the psilomelane miners. Here also were found a few coarse but well-fired pottery sherds and some fragments of animal bones, as well as pieces of haematite, water-worn agates of banded pattern (probably carried there because of their curious appearance), and some slag-like material.

As we did not find any very clear evidence of trimmed and flaked quartz in the Chowa rubble, it was of considerable interest that Kafulamadzi supplied this Late Stone Age facet of the picture (see Plate III, Photograph 4), because the Chowa rubble displayed another curiosity which, in the absence of the Kafulamadzi data, would have been most disconcerting. That curiosity was the presence in the mine rubble of broken perforated stones, broken mullers and grinders, a polished stone axe—in short, fragmentary but unquestionable evidence of neolithic (or polished stone) culture of precisely the same character as was found by us in the "furnace stratum" of the iron-smelting cavern at Mumbwa (see Plate III, Photograph 1).

Taking the evidence of Chowa and Kafulamadzi (which are linked by the common presence of psilomelane) together, it is apparent that the manganese mining community were predominantly Stone Age people but utilising simultaneously the cultural techniques of the Early, the Late, and even the New Stone Ages in exactly the same fashion as and apparently simultaneously with the iron-smelters at Mumbwa.

As a fairly exhaustive illustrated account was given in the Mumbwa paper of practically all the artefact types, to which I will refer here, nothing will be gained by duplicating the illustrations of that paper. The objectives of Mumbwa (iron-smelting) and of Chowa (manganese-mining) being different, however, there are differences in the relative incidence of the artefact types. It will therefore be of value to indicate briefly the forms found and to illustrate (see Plates II and III) by means of a few photographs the unusual material (psilomelane) from which they are, for the most part, formed.

(i) *Stone Hammers.*—Perhaps the most characteristic implements in the Chowa rubble—as of all ancient South African mines—are the stone hammers (see Plate II, Photograph 2). They are coarse blocks of stone, varying from 2 to 8 inches and even more in diameter, whose roughly rounded abraded appearance has resulted from their use as pounders. This type of implement is best illustrated by hammers of intermediate size whose continued use on several aspects has provoked a corresponding number of flattened or depressed facets on the otherwise coarsely spherical mass. Various materials—psilomelane, quartz, quartzite, and even schistose rocks—were utilised at Chowa as hammers, and a great number of well-worn ones, especially those made of quartz, have been fractured in twain by the violence they had finally sustained.

Plate II, Photograph 2, illustrates such hammers made of psilomelane. They have been discovered both at Chowa and Kafulamadzi. In order to depict the similarity between these manganese mining implements and those found in venerable mines elsewhere in Southern Africa, I am illustrating as well (Plate III, Photograph 1) from Transvaal sites a haematite stone hammer (from the old ochre mines at De Doorns) and a granite stone hammer (from the ancient tin mines at Rooiberg). I found similar quartz stone hammers in a cave filled with quartz refuse under the rocks just below the Furnace Enclosure of the Zimbabwe Acropolis. Their use was typical of ancient miners and metal-workers from the Transvaal to the Congo.

In the later type of ancient mine where iron gads were used (as, *e.g.*, the copper mines at Messina and also in the tin mines at Rooiberg) the facets of these hammers are usually more circular and smooth than in those we find at Chowa. Moreover, the stone utilised was usually extremely hard, *e.g.* granite. None of the rocks used as hammers at Chowa were of such hardness as to be very serviceable with a metallic gad. The chisels used were flakes or simple wedge-shaped fragments of stone (to which I will refer later) such as were found also embedded in the ochre at De Doorns and are illustrated by an example in the Anatomy Museum here. Hence the nature of the materials used as hammers bears out the evidence

of the rubble itself that the mining at Chowa was so ancient as to precede the common, or vulgar, use of metals as gads in mining.

(ii) *Coup-de-poings.*—Typical ovate, oval, or circular implements of this class are relatively common in the rubble and exist in great variety from very crude to relatively comely artefacts (see Plate II, Photograph 2). They are made chiefly in psilomelane, but also in quartz and quartzite. They are, however, overshadowed numerically by what may be termed the second most characteristic implement in the manganese-mining.

(iii) *Semi-coup-de-poings.*—These implements, whose type was described and illustrated fully in our Mumbwa paper, are really indistinguishable from the so-called "*side-chopper*" found in Europe in association with implements of river-drift type (see also Plate II, Photograph 2 ; and Plate III, Photograph 3). This type was also described for South Africa, independently of ourselves, by Rev. Neville Jones in a paper published in 1930. In that article, dealing with rostro-carinate implements (found on an open site at Hope Fountain, near Bulawayo in Southern Rhodesia), he points out that

> while the implement might at first sight be mistaken for an ill-shaped *coup-de-poing*, its rostro-carinate affinity is at once apparent when it is placed in the position naturally assumed by this type of implement (*i.e.* with the ventral plane beneath). The ventral plane, though slightly oblique, is a single, or possibly a two-flake surface, long, narrow, and flat, extending nearly the entire length. Though the dorsal plane has been trimmed away in order to obtain a continuous edge, its original position towards the posterior end is clearly apparent owing to the thickening of the edge at that point. Little secondary chipping has been done except to the keel, which is straight and continuous and towards the anterior end in order to form a point. This is rounded and entirely replaces the beak. It is at once apparent that the flaking of the central plane would have provided a typical Chellean *coup-de-poing* and, as an intermediate form in the evolution of that type of implement, the specimen is of considerable interest.
>
> Mr. Moir refers to this implement as "a remarkable example of an early hand-axe exhibiting a transitional stage between the rostro-carinate and the hand-axe. . . . Many implements in every sense comparable with this South African specimen have been found in Southern England."

In the Chowa collection there are specimens identical in character with that so well described and figured by Neville Jones, and there are numerous others that, by carrying the secondary chipping around the keep at its posterior, as well as its anterior end, and by intruding even upon the ventral plate itself (see Plate III, Photograph 3), form a complete evolutionary series from the *rostro-carinate*, through the semi-*coup-de-poing* to the *coup-de-poing* itself. It is therefore interesting that both Reid Moir and Neville Jones are convinced from their study of technique that the hand-axe can be regarded as a derivative of the rostro-carinate.

There is of course no question here (as there was at Hope Fountain) of arguing that, because of the presence of rostro-carinates and semi-*coup-de-poings*, the Chowa manganese deposits are of Early Pleistocene (or Early Acheulean) age; but there is every reason for assuming (as we were able to prove stratigraphically at Mumbwa) that *the local inhabitants of Northern Rhodesia were habitually making these very primitive types of Early Stone Age implements when the metal-seekers and manganese-gatherers came amongst them.*

(iv) *Rostro-carinates.*—True keeled rostro-carinates, both of the sharp and rounded-beak varieties, in psilomelane occur in sufficient profusion to display, as at Mumbwa, the regularity of their use and the abiding influence of the technique, used in making them, upon the whole Chowa industry. As the variants of their manufacture have been so thoroughly illustrated in our Mumbwa paper and in Neville Jones's works, it would be an unserviceable repetition to display them here again.

(v) *Wedges and Chisels.*—In our Mumbwa paper were figured trimmed circular or semicircular "detaching-hammers," more or less lenticular in outline occurring in a very wide range of sizes. It was stated that "their use, other than sling-stones, or possibly as objects of aesthetic value (for they were made of pure white quartz) is not apparent, but some semi-circular types of intermediate size seem to have served as chisels in breaking and flaking the quartz."

At Chowa no room is left for doubt upon this matter owing to the exceedingly wide range of artefacts which have a long narrow and flat ventral plate (essentially derived from rostro-carinate technique), but possess a high keel which replaces completely the remnants of the dorsal plate by a semicircular cutting edge or even a point. Plate III, Photograph 3, illustrates these implements, which doubtless subserved the functions of chisels and wedges. My colleague, Professor M. R. Drennan, informs me that, in the quarrying of stone, quarrymen, through their practical knowledge of the natural cleavage lines, can spectacularly split and detach great blocks of stone by means of comparatively very few, but intelligently directed, blows with a puny hammer and chisel at selected points along its length, thus shattering the obdurate substance as though it were glass. It would appear that practices of this character were responsible for the number of rounded and pointed core and flake tools of chisel-type which litter the Chowa rubble; and I have little doubt that persons with more practical experience of quarrying methods than we possessed, would have selected as tools numerous flakes and cores the functional value of which in such work we, in our ignorance, did not appreciate.

(vi) *Hafted Tools.*—One of the most interesting artefacts yet discovered

in South Africa was a ground and polished stone axe included amidst kitchen-midden material in a cave-shelter at Witsands on False Bay, near Cape Town. This specimen described by Professor M. R. Drennan (1930) differs from all other polished axes hitherto found in South Africa in displaying a polished groove in the superior part of its anterior border whose only service could have been for the purpose of hafting the axe—presumably in the same fashion as the Australian aboriginal hafts his identical grooved axes, "by bending a withy of wood round the groove and tying the two halves of the handle together with string often made of human hair. The head and part of the blade is afterwards encased in wax or resin to fix it more firmly to the handle." As Professor Drennan remarks, the hafting of this axe "is in keeping with the evidence we already have that the Strandlooper fixed wooden handles on certain of his stone implements." That evidence was summarised by Goodwin (1929).

It was therefore fortunate that, on his visit here during 1931, Professor Drennan drew my attention to evidences of hafting in certain of these Chowa implements. A groove, the result of one or more flakes, occurs too frequently just above the "ventral plate" of certain semi-*coup-de-poings* (*i.e.* just below the ventral plate when the tool is placed in the position of use as axes—with their cutting edges downwards) for its presence to be accidental. Such graves would have served admirably in assisting hafting; but the fact that hafting was done is placed beyond doubt in the case of one such implement in which there is a groove in this situation both posteriorly and anteriorly,. and in which a chipped groove almost encircles the head (see Plate III, Photograph 2, No. 3).

The implement which first attracted Professor Drennan's attention in this regard was a slab-like piece of psilomelane ($5\frac{1}{4} \times 2\frac{3}{4} \times 1\frac{1}{4}$ inches), both of whose ends are produced to rude points and about whose girth a definite groove on one side and the smoothing of its anterior and posterior margins indicated that it had been encircled by a hafting of some type such as a cleft stick bound at both ends of the encircling cleft. Such an apparatus would have transformed this intentionally shaped blade into a double-headed pick (see Plate III, Photograph 2, No. 4).

This unexpected evidence of hafting explains the curious form of two other intentionally fashioned psilomelane axe-heads almost identical with one another in form, one coming from the Chowa rubble and the other from a Kafulamadzi rock-shelter (see Plate III, Photograph 2, Nos. 1 and 2). By deft flaking on both sides they have been shaped into axe-heads with typical arcuate cutting edge at one end, while the other is produced as a flange whose swollen (but equally well-shapened) extremity is separated from the main mass of the blade by the scalloping of the anterior and posterior borders of the implement, which thus presents an

hour-glass appearance in lateral view. Evidently this constriction in both cases was intended for assistance in hafting these true axe-heads.

Since hafting was a definite practice on the part of the manganese miners there is every likelihood that many flakes and cores which show little obvious evidence of the adoption of such procedures were none the less similarly treated. It is significant that the hafted stone described by Goodwin was in itself so crude that it would unquestionably have been laid aside as not even being an intentional artefact had it not been found actually hafted *in loco*. But in any case as these manganese miners, like the Strandloopers, were familiar with the technique of both the Late and New Stone Ages, hafting (as of arrow-heads) must have been a regular procedure amongst them both. Satisfaction merely lies in the fact that it can be freely demonstrated also at Chowa in the case of these gross psilomelane tools.

The closeness of the comparison which can be drawn between the hafted implements of Chowa and the flint picks and so-called "paring-knives" from the neolithic deposits of Campigny, Seine-Inférieure, France, should be stressed here. The Campigny culture reflects Moustierian and Magdalenian survivals and presents in addition these picks, paring-knives, pottery, and milling-stones. As MacCurdy says, "The Neolithic tool-maker knew how to produce a straight edge without recourse to the polishing process." That was the case in South Africa as well as in Western Europe.

(vii) *Psilomelane Flake Implements.*—In a sense, being derived from the broken-down lenses of psilomelane, practically all the implements we have discussed are derived from large flakes even though they were shaped by a core technique. The distinction between cores and flakes is therefore a highly artificial one at this particular site; the two merge into one another. Nevertheless, apart from the tools already discussed, there are to be found in the rubble and also at Kafulamadzi a quantity of psilomelane fragments 2 to 5 inches in length, $1\frac{1}{2}$ to $2\frac{1}{2}$ inches in breadth, and $\frac{1}{4}$ to $1\frac{1}{2}$ inches in thickness, which are conveniently separated from the foregoing as flakes. They show rough trimming and form scrapers, knives, and points similar to those produced by Moustierian technique (see Plate III, Photograph 4, Nos. 1, 2, 3, 11, 12, and 13). Actually psilomelane, when fractured, splits up readily into such forms, and little or no trimming is required to produce sharp cutting edges or grinding borders or pointed extremities of rare value for the above-mentioned purposes. Their utility in scraping or chiselling away soft pure manganese inclusion deposits from the psilomelane, or generally as gads, can be readily understood; but the fact that such objects had domestic values as well is shown by their presence also in the Kafulamadzi shelters.

(viii) *Quartz Implements.*—The use of quartz as stone hammers, semi-*coup-de-poings*, etc., has already been referred to. In the Chowa rubble

there is little other evidence of the use of quartz, but at Kafulamadzi quartz is more in evidence than is psilomelane or any other material for service in implement making. But, despite the quantity of splintered quartz on the hill-slopes and in the shelters, it is remarkable how few well-made implements were found.

The neatest example of refined technique discovered was a well-trimmed crescent of "Early Wilton" type (Plate III, Photograph 4, No. 5); but an abundance of "Smithfield" detaching hammers, trimming stones (small and large), untrimmed lanceolate and arrow-point flakes, as well as rostro-carinate forms in quartz, demonstrated a quartz culture indistinguishable from that of Mumbwa, the details of which have already been amply set forth (*loc. cit.*). See Plate III, Photograph 4, Nos. 4, 5, 6, 7, 8, 9, and 10.

(ix) *Pottery and Bone.*—Sherds were found in the Kafulamadzi, proceeding apparently from three different pots, their walls respectively $\frac{3}{4}$ inch, $\frac{3}{8}$ inch, and $\frac{1}{4}$ inch in thickness. The thinner-walled pots are well baked and of fine texture, the thick-walled one is formed of coarse material and the firing is not so thorough. This larger pot was shouldered, and externally, above this region where the circumference was reduced, displayed a coarsely impressed herring-bone pattern. There is nothing to prove definitely that they did or did not belong to the manganese-mining period.

From the few bones found it was possible to recognise a buck, and one of the bones had been smoothed to a blunt point. There was no evidence of domesticated animals nor of perforated bone or shell ornaments.

(x) *Neolithic Objects.*—While I was present at Chowa a polished axe was recovered from the rubble, but by some mischance the specimen was mislaid, and since my return I have been unable to find it. It is not possible, therefore, to give any detailed description of it. It resembled specimen No. 2 described in our Mumbwa paper (fig. 34).

The other specimens that show neolithic technique are perforated stones, mullers, and grinders. Three fragments of broken perforated stones were found in our excavations. They were made of rather soft schistose rock and are small. Plate III, Photograph 1, Nos. 1 and 3, depict two of the specimens.

No. 2 in the same photograph is a representation of a broken grinding-stone (of quartzite), worn concave. Mullers of the unevenly worn variety, usually of quartzite, were also discovered. That the mullers were used for the grinding of manganese is proven by the powdered manganese still present on the polished faces of the slabs. Stone mullers and grinders of this character are regular concomitants of ancient mining processes throughout Southern Africa.

Thus we have in these few documents a complete picture of the processes adopted in the manganese mining from the shattering of the rock to the preparation of the exported powder. Then, as to-day, the fundamental steps in the preparation of pigments were "to select or pick over the raw material, rejecting whatever impurities may weaken or injure the characteristic hue of the product," and then to grind the pigment, for, as our authority states, "with rare exceptions native pigments need careful grinding, either by means of a muller on a slab or by edge rollers or horizontal millstones or special machines." The purity of the final product at Chowa was ensured by the grinding-stones being composed of fine-grained white quartzite.

(xi) *Conclusion.*—We have therefore in the rubble a mixed Rostro-carinate-Palaeolithic-Neolithic assortment of stone implements and a complete absence of metallic and pottery objects. It constitutes the most primitive mining armamentarium described in South Africa or elsewhere, and was probably of correspondingly great age.

3. Discussion.

Knowledge of the earliest phases of mining is rather restricted. Flint-mining was an important industry in England, Sweden, Belgium, France, Spain, Portugal, and Sicily during the Neolithic period, and, as MacCurdy points out in "Human Origins," both the "open cast" or trench and the "gallery" or shaft methods of mining had by then been thoroughly developed. In the Oburg galleries deerhorn picks and flint implements were discovered, the latter being more abundant. At Grime's Graves, near Brandon (Suffolk), there was a most elaborate series of galleries, including "ventilation" holes. Here deerhorn picks, chipped and polished stone implements, and crude pottery were found, as well as four lamps. According to A. L. Armstrong, who made a careful study of the successive deposits at this huge site, four different strata of occupation were disclosed of the Early Iron, Bronze, Neolithic, and ? Maglemose Ages respectively.

The "neolithic" mining of flint was identical with the mining for other minerals, such as copper. They were proceeding simultaneously, and were being exploited by identical tools. As MacCurdy relates:

> The mines of south-eastern Spain are very old. In the Austrian Tyrol, on the Mitterberg Alps, there are prehistoric copper mines and heaps of slag associated with stone implements and with pottery resembling that from the pile dwellings of Mondsee.

In the neolithic pile-dwelling settlement at Robenhausen were found perforated stone hammers and axes, and also crucibles for the melting of bronze and of copper. But copper was in use in Egypt as early as 5000 B.C., and an ingot of gold was found by Quibell in a prehistoric Egyptian grave

at El Kab. As the maximum date for the Neolithic period is the 5th–4th millenia (see Dawson, "The Age of the Gods"), there can be little question that mining on the large scale was carried out first of all in connection with the older civilisation and their metallic requirements, and that this knowledge spread thence westwards to Europe in so-called Neolithic (possibly even in Maglemosian) or even still earlier times.

Primitive as were the methods of the neolithic miners in Western Europe, those of their African (Chowa) brethren were far more crude. The making of galleries, the use of fire-setting (witness the charcoal), the employment of deerhorn picks, perforated stone axes, and the refinements of miners' lamps, torches, and ventilation shafts or vent holes had already become customary in European Neolithic times.

At Chowa we have only the open-cast trench; the *rostro-carinate*, the *coup-de-poing*, the semi-*coup-de-poing*, and the stone wedge and pick are the essential implements. There is only sufficient trace of rubbing technique in a few perforated round stones, a ground axe, and some milling stones whereby to recognise the rudiments of typical neolithic polished stone technique. There is but a glimpse of their acquaintance with hafting, and thereby their capacity to relieve to some extent the crudity of pounding by means of massive stone hammers with elementary stone choppers. There has never been discovered at Chowa the slightest trace of any metallic implement, such as a gad or pick or shovel, of even the crudest character; nor is there any evidence that this people utilised any accessory and apparently obvious method, such as fire-setting, for splitting the resistant rock. Yet manganese is one of the toughest of all ores: it takes ten to twelve blows of a modern iron pick to dislodge even a small fragment from the matrix. This ancient work was all sheer crude hard labour with stone in stone.

From these facts I am persuaded that the *Palaeolithic-Neolithic mining at Chowa is more ancient than that of Neolithic Western Europe.* As a cultural complex it is certainly more primitive. At Mumbwa we found in the primitive (phosphoric-iron bead) smelting cavern the sudden intrusion of a Late Stone Age (Capsian) culture (by means of metal-hunters) upon a Moustierian Rhodesia. This culture had a neolithic facies, but retained palaeolithic and even rostro-carinate (Eolithic) elements. So, too, at the manganese mines of Chowa and the cave-shelters of Kafulamadzi, with their psilomelane and quartz tools, we have discovered the exploitation of magical pigment wealth amidst a Rostro-carinate-Palaeolithic-Moustierian Rhodesia by similar bringers of a similar Late Stone Age (Capsian) culture with an identical neolithic facies. The comparison is so exact that I have no hesitation in identifying the exploiters of phosphoric iron at Mumbwa with the gatherers of manganese at Chowa.

The Chowa discovery has particular significance in that manganese has no known use in the eyes of living African natives. Manganese was, however, freely used in Ancient Egypt and Mesopotamia as a pigment and cosmetic, and gave the valuable brown, purple, and black colours aimed at so frequently in ancient pottery glazes and in glass.

In glazes and in glass manufacture manganese also had the magical power of modifying the hues in the reds of iron-ore pigments and the blues of copper-ore pigments. This power of manganese, too, lay behind the discovery of colourless glass which was of great antiquity.

Manganese may also have been used in the ancient civilised world as a dye and a mordant for other dyes, and it is known to have been used in Mycenean times in certain metallurgical cementing processes.

These uses of manganese postulate the presence in Northern Rhodesia at a remote "Stone Age" period of an intelligent foreign mining people familiar with some or other of all of the manifold uses of manganese.

The time at which the manganese-mining was done in Northern Rhodesia and who the people were who performed it are matters not easy to determine, but guesses may reasonably be hazarded on these matters.

The only positive datum concerning the age of the Chowa mine is that "stringers," which could not possibly have been overlooked by the ancients, were exposed to a height of 6 inches. In other words, at least a foot of soil denudation must have taken place over the hillside since the mines were worked. Any other chronological reasoning must be inferential and is based upon the identities between Chowa on the one hand and Mumbwa on the other.

There is a very close resemblance between the stone implements of Chowa and those of Mumbwa. The stratigraphical evidence at Mumbwa indicated that the furnace deposit was to be regarded as at least 2000, and possibly 4000 B.C. To a similar date we may attribute the manganese-mining at Chowa—a date which would render easily comprehensible the Rooiberg (Transvaal) association of stone implements with copper, tin, and bronze enterprise described by the late Dr. Percy Wagner, if they had been conducted by an ancient civilised people such as the Egyptians or Sumerians. For these people were then still in a state of mixed (stone and metal) culture, but were none the less at the zenith of their metallurgical and artistic enterprise.

In conclusion, I wish to express my gratitude to the late Mr. Stevens, Manager of the Broken Hill Mine, and his staff for their drawings and many other kindnesses, to Messrs. Gimkey and Drysdale of the Engineering Department here for their assistance in preparing the final diagrams, and to Professor R. B. Young for identifying the specimens geologically.

PHOTOGRAPH 1.

Kafulamadzi Hills, three miles from Broken Hill, Northern Rhodesia, and the underlying plain, to illustrate the territory occupied by the manganese miners.

PHOTOGRAPH 2.

A typical rock-shelter amongst the quartzitic boulders of Kafulamadzi. Five such shelters revealed the presence of manganese implements and flakes taken from Chowa.

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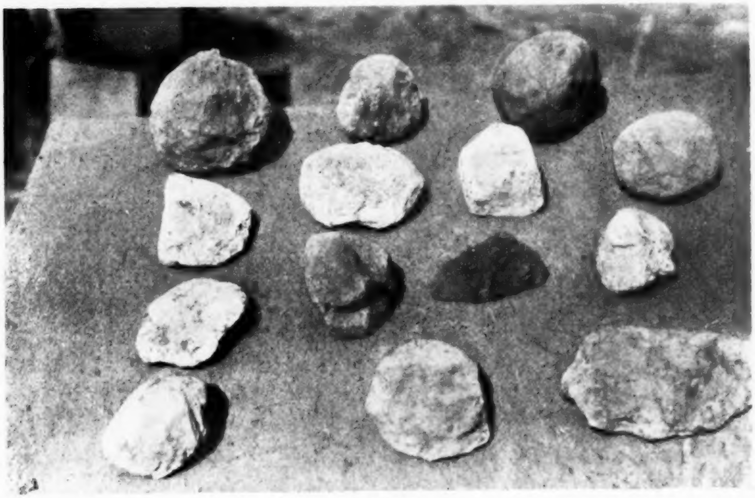
PHOTOGRAPH 1.

The Chowa manganese mine site, demonstrating the masses of crudely and finely broken manganese detritus excavated from a small portion of the ancient stoeps. The present miners sift the rubble of the ancient miners to eliminate the quartzite, schist, etc., imported by them.



PHOTOGRAPH 2.

Coarsely rounded hammer-stones of psilomelane and quartzite and artefacts of palaeolithic type (in the form of *coup-de-poings* and semi-*coup-de-poings*) in the same materials, used by the ancient miners and found in their rubble.

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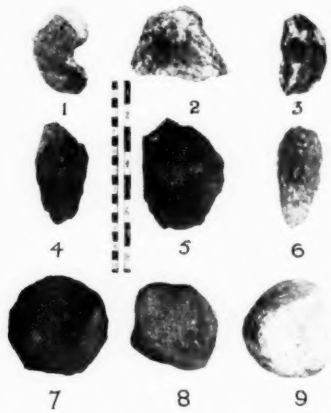
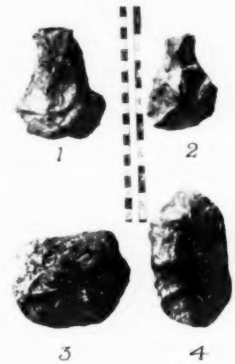
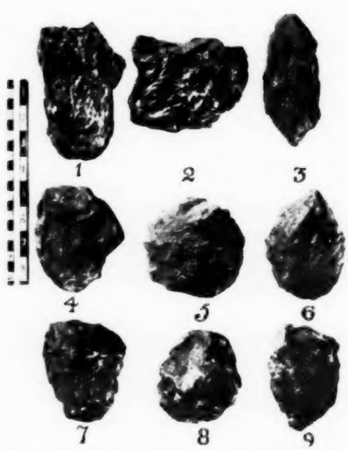
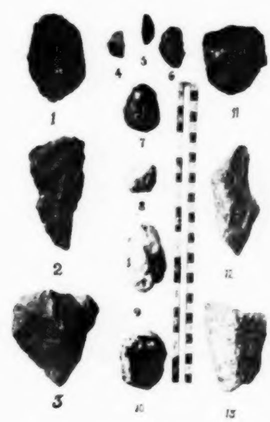




Photograph 1.—Series of artefacts from Chowa rubble. Nos. 1 and 3 broken perforated stone formed of schist. No. 2 a white quartzite grinding-plate smeared with ground manganese powder. Nos. 4, 5, and 6 chisel-like wedges in psilomelane and quartzite. No. 7 a psilomelane hammer-stone from Chowa. No. 8 a granite hammer-stone from the ancient tin mines at Rooiberg in the Transvaal. No. 9 a haematite hammer-stone from the ancient ochre mines at De Doorns in the Transvaal.

Photograph 2.—Artefacts in psilomelane from the Chowa rubble and the Kafulamadzi rock-shelters to illustrate hafting. No. 1 an axe-head from Chowa. No. 2 an axe-head from Kafulamadzi of virtually identical form. No. 3 a semi-*coup-de-poing* grooved anteriorly and posteriorly near the flattened "head," or base. No. 4 a pick-like artefact constricted around the middle portion for the probable attachment of withes.





Photograph 3.—Artefacts in psilomelane from the Chowa rubble. Nos. 1, 2, and 3 wedge-like forms. Nos. 4, 5, and 6 hand-axes of the semi-*coup-de-poing* type, and possibly hafted for use. No. 7 a double-headed pick. No. 8 a combined pick and axe. No. 9 a coarse pick.

Photograph 4.—Series of artefacts from the Chowa rubble and the Kafulamadzi rock-shelters to show correspondences. Nos. 1, 2, and 3 are from Kafulamadzi, and may be strictly compared with Nos. 11, 12, and 13 from Chowa. Nos. 1 and 11 are chisel forms; Nos. 2 and 12 are flake forms (? knives); and Nos. 3 and 13 are "pick" forms. Nos. 4, 5, 6, 7, 8, 9, and 10 are implements in quartz accompanying the psilomelane in the Kafulamadzi shelters. Nos. 4 and 6 are points (? arrow-heads). No. 5 a true (Early Wilton) crescent. No. 8 a lance-head. Nos. 8, 9, and 10 are trimming stones of which 9 is rostro-carinate in form.

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THE INFLUENCE OF FLUORIDES ON THE REDUCTION OF PERMANGANATE.

Part II.—Potentiometric Titrations with Antimonious Salts, Arsenious Acid, Potassium Iodide, and Hydrogen Peroxide.

By W. Pugh.

(With six Text-figures.)

The influence of fluorides on the reduction of potassium permanganate by antimonious salts has been described in a previous paper (1), which also includes references to previous work on the subject. It is therein shown that antimonious ion reduces permanganate in the presence of fluoride, within certain limits of acidity, as far as trivalent manganese only. Fluorides stabilise trivalent manganese through the formation of stable mangani-fluorides. If this is true, fluorides should have the same effect on reductions carried out with other reducing agents, and the present investigation was made to test this point.

In the previous investigation only the final valence condition of the manganese was considered, and in order, if possible, to get some information about the actual course of the reduction, use was made of electrometric titration, and for this reason antimony salts are again included.

Experimental Part.

The solutions to be titrated were placed in glass vessels which had been coated with paraffin wax, and a similar coating was applied to all glass parts that came in contact with the fluoride solutions. The liquid was stirred mechanically. A bright platinum wire dipping into the liquid formed one electrode; this gave better results than a platinised electrode. The saturated calomel formed the other electrode, the two being connected through a potassium-chloride bridge. The E.M.F. of the cell was measured at intervals after each addition of titrating liquid, and the values obtained were plotted against the volume used. In some cases equilibrium values were established rapidly; in others, equilibrium was only slowly set up, and in such cases the values plotted are those established after a definite interval of time. In all cases the E.M.F. plotted is the actual E.M.F. of

the cell, and represents, therefore, the potential of the platinum electrode when that of the calomel electrode is taken as zero.

Reduction with Antimonious Ion.—The results obtained by titrating a solution containing 5·947 grams of pure antimony per litre (·0977N) with potassium permanganate (·0906N) are given in fig. 1. 20 c.c. of the antimony solution in a total volume of 180 c.c. were used. Curve I. is that for a solution containing 15 per cent. by volume of concentrated hydrochloric acid. The sharp break occurs at the theoretical equivalent point for reduction to divalent manganese, as shown previously by the author (2). The remaining curves are those for solutions containing 5 grams of potassium fluoride and different quantities of acid in the same total volume. The break in these curves does not occur until 25 per cent. more permanganate is added, and even in the presence of considerable acid it is still fairly sharp. Thus, in presence of fluorides, potassium permanganate is reduced according to the equation—

$$2MnO_4' + 2Sb_2O_3 + 8H^+ = 2Mn^{+++} + 2Sb_2O_5 + 4H_2O.$$

Reduction with Arsenious Acid.—The reduction of permanganate by arsenious acid has been well studied on account of its use in the Proctor Smith method for estimating manganese in steel. A good bibliography on the subject is given by Hall and Carson (3). It is established that in the presence of sufficient hydrochloric acid arsenite is completely oxidised and the permanganate completely reduced to divalent manganese, while in the presence of other acids reduction of permanganate is far from complete and its extent varies with the conditions. Swoboda (4) has shown that titration may be made, in presence of fluorides, fairly accurately to the manganic stage, over a wide range of acidity.

The results of a few electrometric titrations on a solution containing 4·484 grams of pure arsenious acid per litre are plotted in fig. 2. Curve I. is that given in the absence of fluoride in a solution which is 2·5N with respect to hydrochloric acid. Under these conditions, permanganate is reduced to divalent manganese according to the equation—

$$4MnO_4' + 5As_2O_3 + 12H^+ = 4Mn^{++} + 5As_2O_5 + 6H_2O,$$

and the equivalent point is marked by a very sharp rise in potential. The remaining curves show the influence of 5 grams of potassium fluoride in presence of varying amounts of acid. In dilute acid (curve IV.) permanganate is reduced exactly to trivalent manganese, but with larger amounts of hydrochloric acid (curve II.) there is a tendency for partial reduction to divalent manganese. The influence of fluoride is countered by increasing the hydrochloric acid concentration. Sulphuric acid has a much smaller effect in this respect.

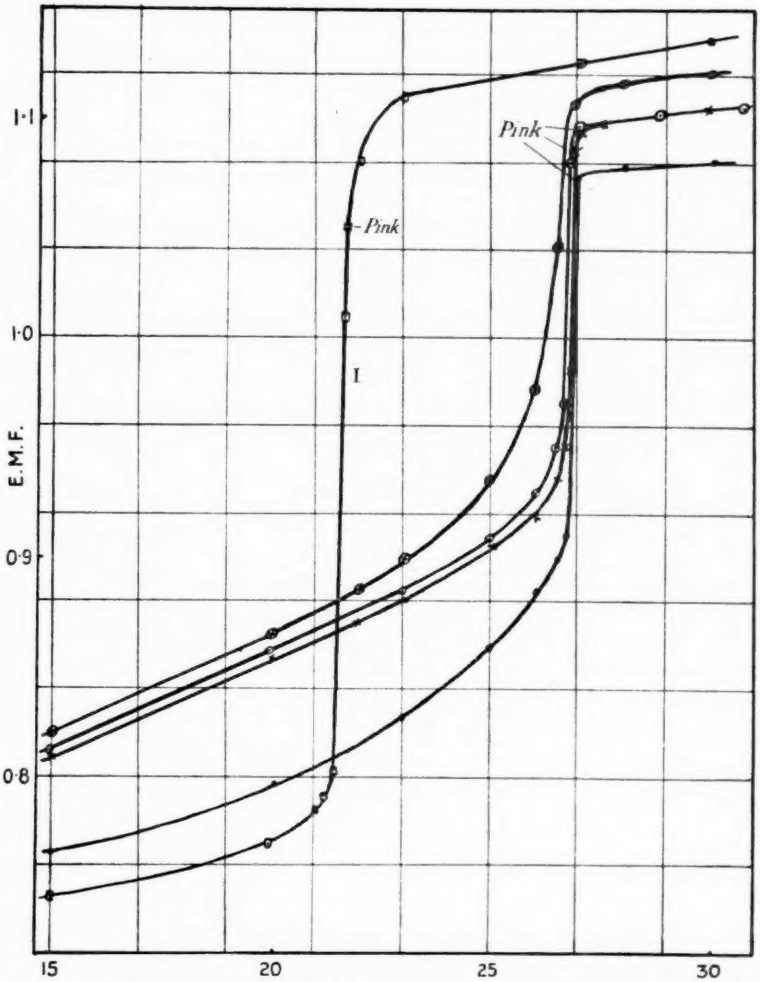

FIG. 1.—20 c.c. antimony solution (·0977N) *versus* potassium permanganate (·0906N) (volume 200 c.c.).

c.c. $KMnO_4$.

● 20 c.c. antimony + 10 c.c. 5N HCl + 5 grams KF.
× ,, ,, + 15 ,, ,, ,, ,,
○ ,, ,, + 20 ,, ,, ,, ,,
⊗ ,, ,, + 10 ,, ,, + 10 c.c. 5N H_2SO_4 + 5 grams KF.
□ ,, ,, + 60 ,, ,, (no fluoride).

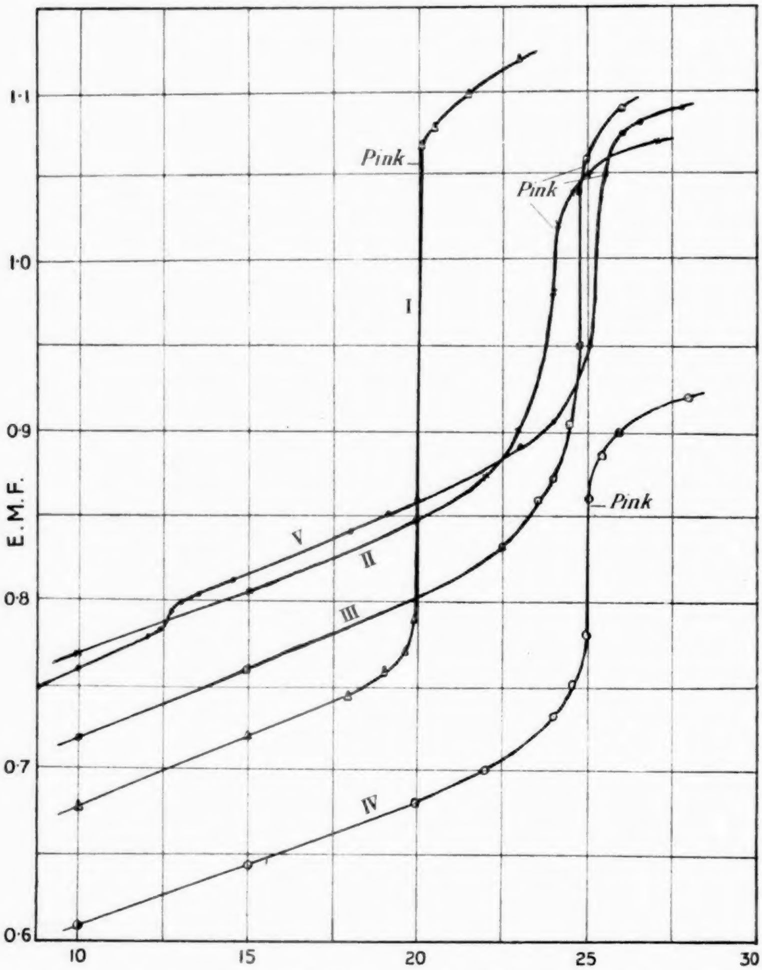

FIG. 2.—20 c.c. arsenious acid (·0906N) *versus* potassium permanganate (·0906N) (volume 200 c.c.).

c.c. $KMnO_4$.

○ 20 c.c. As_2O_3 + 10 c.c. 5N HCl + 5 grams KF.
× ,, ,, + 20 ,, ,, + ,, ,,
□ ,, ,, + 40 c.c. 5N H_2SO_4 + 5 grams KF.
△ ,, ,, + 100 c.c. 5N HCl.
● 10 ,, ,, + 10 c.c. Sb_2O_3 + 20 c.c. 5N HCl + 5 grams KF.

Curve V. shows the result of titrating a mixture of 10 c.c. each of the arsenious acid and antimony solutions. There is a distinct break at the stage at which the arsenious acid alone is oxidised, but it is not sharp enough to be made use of for the estimation of arsenic in the presence of antimony.

The reverse titration of permanganate by arsenious acid in acid solution is shown in fig. 3. The electrode assumed equilibrium rapidly in these

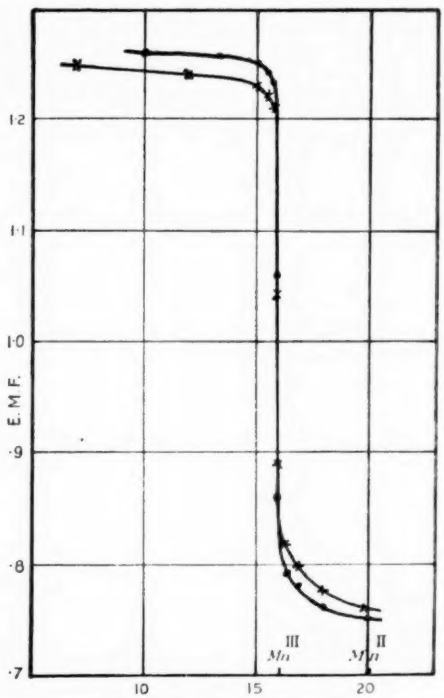

FIG. 3.—20 c.c. potassium permanganate (·0906N) *versus* arsenious acid (·0906N) (volume 200 c.c.).

c.c. arsenious acid.

● 20 c.c. $KMnO_4$ + 5 grams KF + 40 c.c. 5N H_2SO_4.
× ,, ,, + ,, ,, + 80 ,, ,,

cases, but there was no indication of reduction to manganate or manganese dioxide. The only break corresponds exactly with reduction according to the equation—

$$2MnO_4' + 2As_2O_3 + 8H^+ = 2Mn^{+++} + 2As_2O_5 + 4H_2O.$$

Swoboda's observations are therefore confirmed, and, since the end point can be more accurately located, potentiometric titration of the permanganic acid with arsenious acid can be recommended for the estimation of manganese in steel.

Reduction with Iodides.—According to Hendrixson (5), iodides can be titrated in acid solution with permanganate with great accuracy, and a typical curve for the titration is given in fig. 4, curve I. The influence of fluorides in this case, however, becomes apparent in low acid concentrations only. This is shown in curves II., III., and IV. The arrest of the reduction at the trivalent stage is possible only at much lower acid concentrations than in the case of arsenious acid or antimony salts. This, however, is precisely what is to be expected, because iodides are much stronger reducing agents in acid solution than either of these.

Reduction with Hydrogen Peroxide.—When potassium permanganate is reduced with hydrogen peroxide the valence of the manganese in the reduced condition varies according to the hydrogen ion concentration of the solution. When this is high, reduction is complete to divalent manganese, as was shown by Brodie (6). In neutral or faintly acid solution, Martinon (7) found that a precipitate was formed, the composition of which varied between hydrated manganic oxide and manganese dioxide and seemed to depend on the acidity and on the rate at which hydrogen peroxide was added. The course of the reduction is clearly indicated in fig. 5, where curve I. shows the result of titrating potassium permanganate in a solution approximately 1·4N with respect to sulphuric acid. Equilibrium is established in about 5 minutes in this case. During the early stages of the titration a reddish-brown precipitate appears, even in presence of so much acid, and this persists until about 0·8 equivalent of hydrogen peroxide is added. The addition of more peroxide causes the precipitate to dissolve, and it disappears completely and the solution becomes clear when exactly one equivalent is added. This point corresponds to the sharp break in the curve and to reduction to divalent manganese. The earlier break occurs approximately at the manganic stage, and, with the appearance of the precipitate, is evidence that reduction of permanganate in the presence of acids proceeds through the intermediate manganic stage. There was no evidence of a break at the manganate stage.

The influence of fluoride in all these reductions confirms this view, the reduction being arrested at the manganic stage. In the case of hydrogen peroxide, the influence of fluoride is shown in curves II. and III. When the acidity is not too high (curve II.) there is a very sharp break at the manganic stage and beyond this the potential falls away gradually. At the same time, the solution loses its faint orange colour, becoming colourless at the manganous stage. Although there is only one break in the

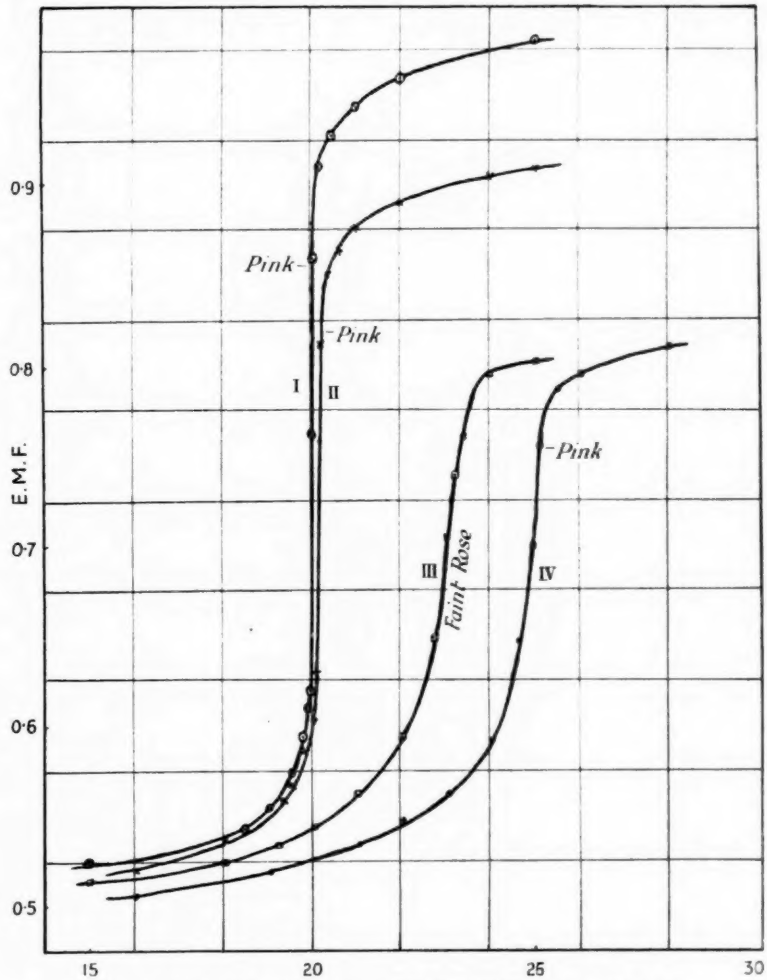

FIG. 4.—20 c.c. KI (·0906N) *versus* $KMnO_4$ (·0906N) (volume 200 c.c.).

c.c. $KMnO_4$.

○	20 c.c. KI + 10 c.c. 7N H_2SO_4 (no fluoride).					
×	,,	,, + 10	,,	,,	+ 5 grams KF.	
●	,,	,, + 10	,,	,,	+ 10	,, ,,
□	,,	,, + 5	,,	,,	+ 5	,, ,,

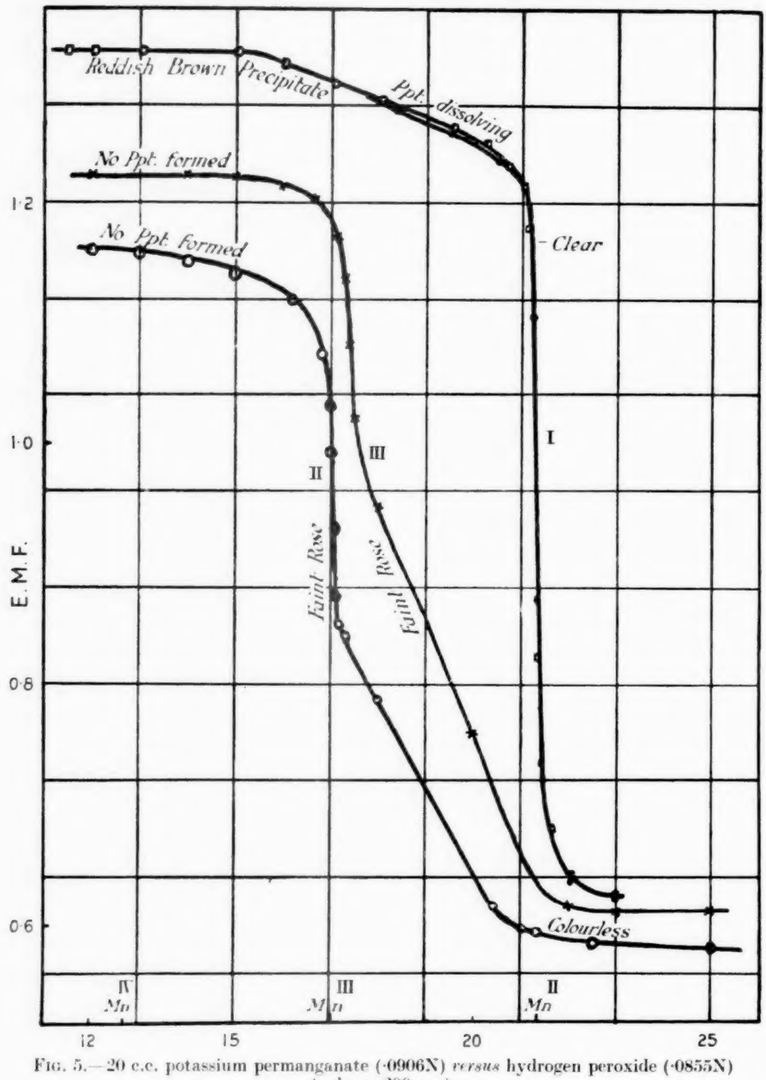

Fig. 5.—20 c.c. potassium permanganate (·0906N) *versus* hydrogen peroxide (·0855N) (volume 200 c.c.).

c.c. hydrogen peroxide.

○ 20 c.c. $KMnO_4$ + 20 c.c. 7N H_2SO_4 + 10 grams KF.
× ,, ,, + 40 ,, ,, + 10 ,, ,,
□ ,, ,, + 40 ,, ,, } no fluoride.
● ,, ,, + 20 ,, ,, }

curve, corresponding to the manganic stage, the colour change which follows does suggest that reduction to the manganous stage takes place with further addition of peroxide. The slope of the curve suggests the same thing because it is much greater than would be expected if it were due to the excess hydrogen

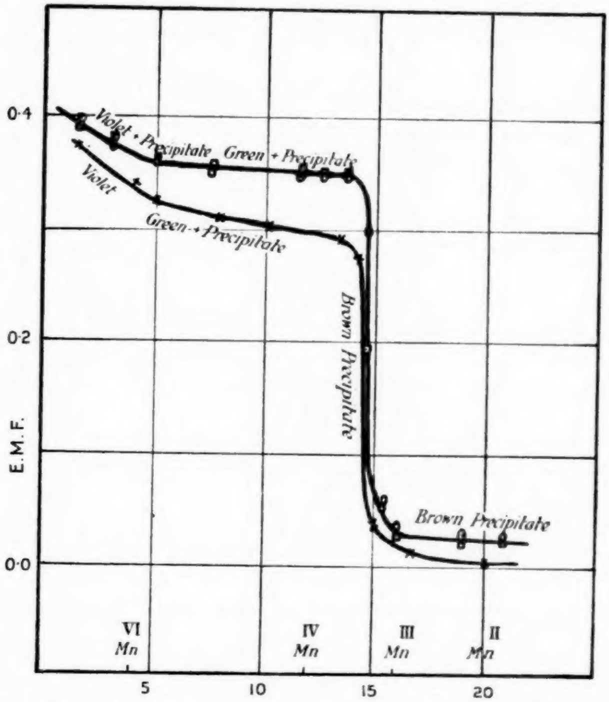

FIG. 6.—Alkaline potassium permanganate 20 c.c. (·0906N) *versus* hydrogen peroxide (·090N).

c.c. hydrogen peroxide.

□ 20 c.c. $KMnO_4$ + 4 c.c. $\frac{N}{2}$ KOH + 5 grams KF/100 c.c.
○ ,, ,, + 4 ,, ,, /100 c.c.
× ,, ,, + 30 ,, ,, + 5 grams KF/100 c.c.

peroxide added. But if, at the manganic stage, the manganese is present as a complex of the type $(MnF_5)''$, and this is only slightly dissociated, the change in potential with reduction will be rapid because the manganous ion concentration will change rapidly while the manganic ion concentration will remain practically constant at a low value. A tenfold increase in the ratio of the ionic concentrations should change the potential by 59 millivolts.

In alkaline solution reduction takes quite a different course. A few of the results under these conditions are given in fig. 6. These show that the first reduction product is the manganate and the final one a mixture of hydrated manganic oxide and manganese dioxide. Fluorides have no influence at all in alkaline solution. During the titration of the more strongly alkaline liquids the colour changed from dark violet to green almost exactly at the manganate stage, but in the weakly alkaline liquids the appearance of the green colour was delayed and a considerable amount of a brown precipitate appeared before the liquid turned green. This agrees with the observation of Mitscherlich (8) that manganates are decomposed by water yielding a red solution of permanganate and a deposit of hydrated manganese dioxide.

It is clear, then, that when permanganate ion is reduced in the presence of fluoride ion there is a tendency for the reduction to be arrested at the manganic stage. This tendency is very strong when reduction is effected with the weaker reducing agents and it is strongly countered by high concentrations of hydrochloric acid. Nothing has been found in this investigation to conflict with the accepted view that the fluoride ion functions through the formation of stable complex mangani-fluorides. On the contrary, the curves for reduction with hydrogen peroxide afford powerful support for this view.

University, Cape Town.

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CLIMATIC CHANGES AND THEIR EFFECT ON FRESH-WATER MOLLUSCS.

By F. G. Cawston, M.D., Cantab.

The collection of pond-snails during the last few years has been handicapped by the lessened rainfall in many districts in the mountainous parts of the Union and by anti-malarial measures which have been adopted in coastal areas, whereby small collections of water have been treated with chemicals and much of the vegetation on which pond-snails breed has been destroyed.

Prolonged drought has occasioned the death of rushes and the larger water plants in mountainous marshes, so that the streams now contain smaller weeds on which one is more likely to find such small molluscs as *Ancylidae* and *Lymnaea truncatula*, instead of *Bulinus*, *Lymnaea natalensis*, and *Physopsis africana*, which may be expected along the banks of rivers containing the large rush, *Cyperus immensus* C. B. Clark.

Following a snowstorm in Southern Basutoland in 1902 there has been a disappearance of the wild olive, and fuel has become a constant problem in this mountainous district. A similar experience is noted in the Transkei, where the Xuka river was once characterised by its beautiful indigenous trees, but is now obvious because of the absence of tree life.

Pond-snails favour shady portions of shallow water, and the absence of rains have recently discouraged the breeding of all but those which are largely dependent on light, such as *Lymnaeae* and *Ancylidae*. *Ancylidae* can resist desiccation for several months by attaching themselves to a rush; *Lymnaeae* are dependent on light, and it has not yet been clearly shown how they can survive desiccation. Burying would seem to kill them, and it is difficult to find them amid the dry mud of shallow pools. As the return of rains is accompanied by numerous small examples of a species, it would seem that it is the young examples or even the egg-masses that survive a winter drought.

Though Fasciola infection may be spread in the Union of South Africa by examples of *Lymnaea natalensis* Krauss, infestation of this species is rare, and I do not remember to have encountered the infection except in examples obtained from Durban, Natal, and Lake Chrissie, Transvaal. The infection may also be spread by the larger *Lymnaea* in other countries, by *Lymnaea brazieri* in Australia and by *Lymnaea pereger* in Wales; but

there would seem to be no reason to doubt that *Lymnaea truncatula* Müller is the favourite intermediate host for Fasciola infection in Europe and wherever else it is found.

Fluke disease of sheep was recognised as of economic importance in the Mokhotlong district of Basutoland in vleis at altitudes of between eight and ten thousand feet, and I was able to recognise *Lymnaea truncatula* from that locality. I have found this species also in shallow, shady streams at Heidelburg, Transvaal, in the dry season, and have collected numerous examples at Kokstad after a dry period of the year.

Experiments to show the effect of desiccation on the various intermediate hosts for trematode parasitic worms in South Africa have shown that, while carriers of Schistosoma will resist burial in garden soil for several weeks at a time, *Lymnaea* rapidly die for lack of light. Experiments with *Lymnaea truncatula* and allied pond-snails in the United Kingdom have shown that *Lymnaea truncatula* is more resistant to desiccation than either *L. pereger*, *L. palustris* or *Planorbis spirorbis* when lying on the surface of mud, and that they resist exposure to frost to which *Planorbis* succumbs.

We have reason to believe, then, that the environmental influences to which pond-snails have been exposed in the Union during the last few years have been detrimental to the breeding of *Physopsis africana* Krauss, *Bulinus tropicus* (Krauss), *Lymnaea natalensis* Krauss and allied species, and that the shortage of rainfall and the consequent increase of marsh land in the mountainous districts has favoured the breeding of smaller species such as *Lymnaea truncatula* Müller, a well-known carrier of Fasciola infection.

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THE GROWTH CHANGES OF *PTEROPLATEA NATALENSIS*, G. AND T.

By J. L. B. Smith.

(With Plate IV and one Text-figure.)

Family DASYBATIDAE.

Genus Pteroplatea, Müller and Henle.

1913. Garman, Mem. Mus. Comp. Zool. Harv., p. 412.
1925. Barnard, Ann. S.A. Museum, vol. xxi, p. 80.

To the diagnosis of this genus add the following: "An ovoid flap of the iris extending over the pupil from the upper margin, increasing with age. A wide but low crenulate cutaneous flap on floor and on roof of mouth, behind the dental laminae, may be present. A small tentacle, on the inner posterior margin of the spiracle, sometimes present, decreasing with age, possibly becoming obsolete in large sexually mature individuals."

Pteroplatea natalensis, G. and T.

1911. Gilchrist and Thompson, Ann. S.A. Mus., vol. xi, pt. 2, p. 56.
1925. Barnard (*loc. cit.*), p. 81.

The holotype of this species is a juvenile male from Natal, 280 mm. across the disc. It possesses a small pointed tentacle on the inner posterior margin of the spiracle, while the disc is markedly triangular in shape, with undulate anterior margin. The caudal spine has been stated not to be serrate, but this is an error. The serrations are present, but are hidden under the skin or by a coating of mucus.

The only other species recorded from South Africa is *micrura*, Bl. Schn. The identification is based upon two large specimens, one stuffed, one cast (from the Agulhas Bank), in the S.A. Museum. This species has no tentacle, and the disc is subrhomboidal in shape.

Very little appears to be known about the habits and development of species of this genus, nor, in so far as I have been able to ascertain, have the growth changes of any species been previously described.

The present work is based upon the examination of a graduated series

of specimens, ranging from 104–1830 mm. across the disc, secured in the course of experimental netting in the Knysna estuary.

These fishes appear to enter the river chiefly during the late summer and early winter months, but have been observed throughout the year. Of the specimens mentioned above, only two were sexually mature. These were gravid females, 1790 and 1830 mm. across the disc respectively, and each proved to hold eight embryos. The smaller of the two was taken near the mouth of the river, while the larger was captured about seven miles higher, where the salinity of the water is very considerably lower than that of the sea. The netters state that very large as well as very small specimens are by no means infrequently taken in the autumn. It is possible that gravid females may seek out the more protected waters of the river to give birth to the young. Since, however, sexually immature individuals are as frequently present, it is possible that the entering of the river may be purely fortuitous, for the mouth of the Knysna River is both wide and deep.

In so far as may be judged from the stomach contents, the food of these fishes appears to consist of small fishes (*Sparus sarba* Forsk. and *Mugil* sps.) and crustacea, chiefly crabs.

The larger of the two gravid females to which reference is made above might easily have been mistaken for a specimen of *micrura*, since there was no trace of a spiracular tentacle, and the disc was much less triangular in shape than that of the type of *natalensis*. The embryos it contained (5 ♀, 3 ♂) are, however, quite apparently conspecific with *natalensis*, since these all possess the spiracular tentacle, and are even more markedly triangular in shape than the type. These embryos (104–117 mm. across the disc) are far from mature: the appendicular yolk-sac is large, the caudal spine is unossified and adnate, while chromatophores are not visible, and filamentous external accessory gills are present. In the smaller of the two females (1790 mm.) the spiracular tentacle has been reduced to a mere knob, while the disc resembles that of the larger female. The embryos (6 ♀, 2 ♂, 265–280 mm. across the disc) are in this case mature. The yolk has been fully absorbed, external gills are absent, the coloration is fully developed, and the caudal spine is ossified, serrate and free. All possess the spiracular tentacle. One of these is shown in Pl. IV, fig. 2.

Embryonic Forms.

The width of the disc in the embryos is 1·6–1·7 times the length (tip of snout to level of hind margin of disc). The mid-point of the line joining the pectoral apices is 3·5–5·0 times as far from the tip of the snout as from the hind margin of the disc (in the type specimen 4·3). There does not

appear to be any appreciable change in the shape of the disc from the early to the later stages of embryonic development. The interorbital width is 0·9–1·3 in the snout (for convenience measured from midway between the centres of the eyes to the anterior point of the disc). In the very small specimens the eyes are pedunculated, and the developing iridal flap shows as a small but sharp convexity at the upper margin of the pupil. The caudal is 1·3–1·8 in the length of the disc, with a moderate cutaneous fold above and below. The ossification of the caudal spine is evidently one of the later processes of embryonic development, possibly taking place while the whole spine is adnate to the body of the caudal. The accessory external filamentous gills of the very small specimens are considerably longer than the disc. The coloration of the mature embryos is very similar to that of half-grown individuals, except that numerous round spots are more obvious.

Post-natal and Mature Stadia.

The disc changes from subtriangular to subrhomboidal with growth, becoming also relatively broader (fig. 1, A–F). The posterior margin of

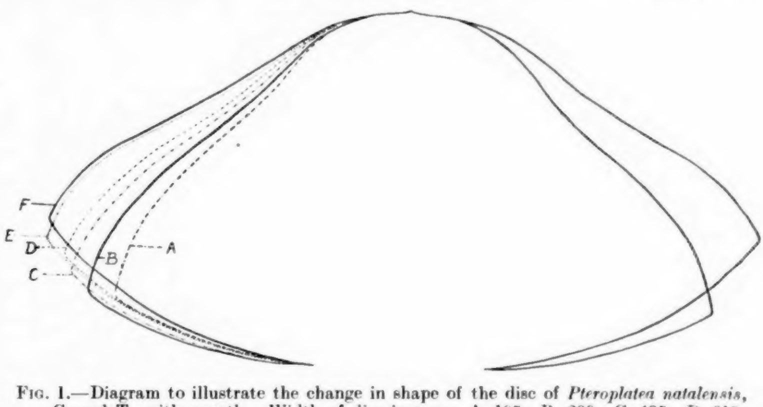


FIG. 1.—Diagram to illustrate the change in shape of the disc of *Pteroplatea natalensis*, G. and T., with growth. Width of disc in mm.: A, 105; B, 280; C, 435; D, 610; E, 1080; F, 1830.

the disc is gently convex, sometimes finely scalloped. The anterior margin of the pectoral is gently undulate, with concavity about midway between pectoral apex and snout. The pectoral apices become less obtuse with growth. The interorbital width is equal to or slightly greater than the snout (see above). The eyes are prominent, and the iridal flap in the larger specimens covers most of the pupil. Length of spiracle about 2·5 in interorbital width, which is 10–12 in disc width. The

spiracular tentacle in young and half-grown individuals is slender and pointed, 8–10 in spiracle length; apparently diminishes with age. Caudal small, diminishing in relative length with growth (the accidental shortening of this organ by injury is frequently observed in Dasybatids). Cutaneous fold, above and below, moderate. One or, more usually, two serrated spines near caudal base, short and stout. No dorsal fin or, as observed in one case, a mere rudiment, reduced to a small fold of thickened skin immediately anterior to the caudal spines. Skin smooth. Teeth tesselate, each rhomboidal base with a flattened triangular retrorse point. The number of the teeth in each row and the number of rows increases from 40 rows of 8–10 each in the smaller to 110 rows of 15–20 each in the largest specimens. Anterior and posterior margins of each lamina undulate: the upper lamina with anterior median convexity, the lower with median anterior concavity (Pl. IV, A and B). (Barnard's comment, *loc. cit.*, p. 81, on the paragraph about the dental laminae in the original description is rather severe. The meaning of this rather obscurely worded paragraph becomes clear when the laminae are examined.) Colour uniform brown above, or with darker or lighter vermiculations and blotches, light below. Tail with alternate dark and light annulations, becoming obscure in adults.

The following table indicates the chief changes which take place with growth :—

Sex.	F.[1]	M.[2]	M.[3]	F.	F.	F.[4]	F.	F.
Width disc in mm.	105	265	280	435	610	1080	1790	1830
Length disc in width	1·6	1·7	1·75	1·85	1·9	2·1	2·1	2·0
Caudal in disc length	1·5	1·8	2·0	2·5	2·0	2·1	2·5	3·3
Pectoral line [5]	5·0	4·2	4·3	3·2	2·6	1·95	1·6	1·6
In fig. 1	A	..	B	C	D	E	..	F

[1] Most triangular immature embryo.

[2] Plate IV, fig. 2. [3] Type specimen. [4] Plate IV, fig. 1.

[5] The number of times that the mid-point of the line joining the pectoral apices is farther from the tip of the snout than from the posterior margin of the disc.

This species is very closely related to *altavela* Linn., from the tropical Atlantic, from which it apparently differs in the markedly triangular disc, in the more obtuse pectoral apices and in the more more undulation of the anterior margins of the pectorals. These differences are slight, especially since *altavela* appears to be of somewhat variable form. Garman (*loc. cit.*, p. 415) considers *canariensis* Val., *valencienni* Dum., and *vaillantii* Rochebr. conspecific with *altavela*. It is possible that the earlier figures of species are not always to be relied upon, but I have seen those of these

synonyms, and they differ very considerably one from the other. It is not unlikely also that very different stadia have been figured.

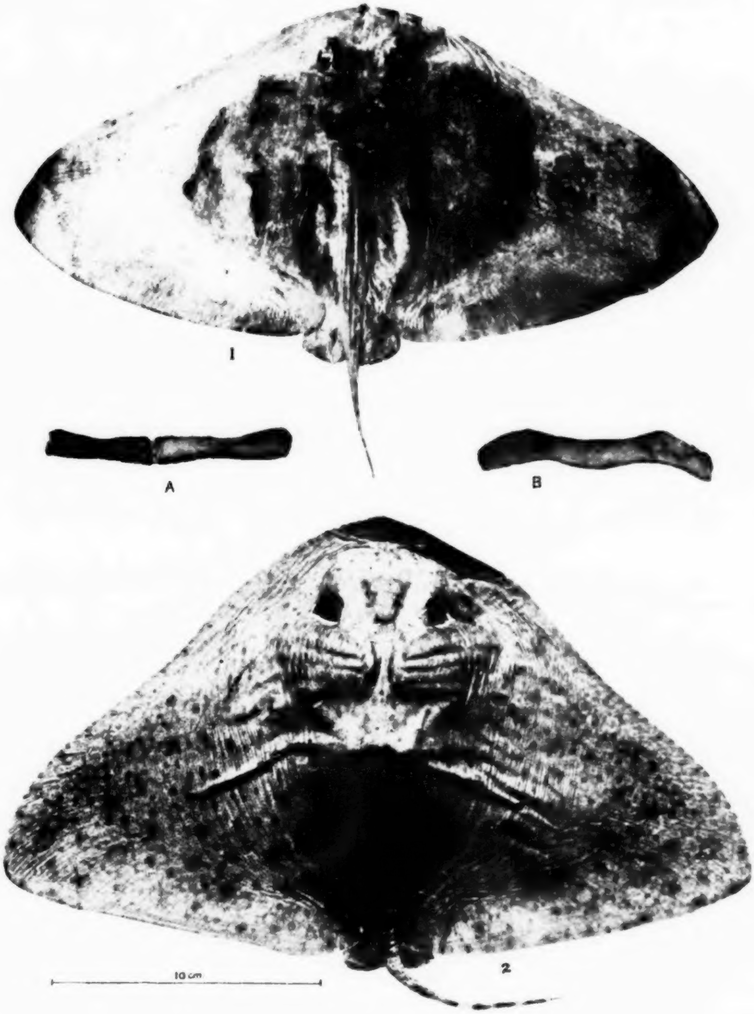
I may here call attention to the fact that descriptions of the species of this genus rarely include the precise size of the specimens described, which, in view of the evidence here adduced, considerably diminishes their value. It would not indeed be surprising if *natalensis* were to be found conspecific with *altavela*. Barnard, *loc. cit.*, probably had some such idea, since he remarks that the adult of *natalensis*, when found, would probably be found referable to a previously known species. I do not feel justified in pronouncing *natalensis* a synonym of *altavela*, since I have seen no authentically named specimens of the latter.

It may be remarked that the growth changes of *natalensis* indicate that a revision of this genus, based upon adequate material, would probably result in a somewhat drastic limitation of the number of species. It is evident that the shape of the disc, the length of the caudal, and even the presence or absence of the spiracular tentacle are, unless many equivalent stadia are compared, not as reliable a guide to the differentiation of species as may hitherto have been supposed.

At Knysna, *natalensis* is named "Backwater" by the netters: when caught, the fish lies flat against the net and so renders the retraction extremely arduous. The species is for this reason an extremely unwelcome capture, and also, in addition, since its presence in the net appears to terrify the other fishes, great numbers of whom escape by jumping over the net. At Knysna this species is seldom taken on lines, but farther east it is not an infrequent capture. A large specimen of presumably this species was recently taken on a line in the Keiskama River, and in Natal waters it is no infrequent capture, large specimens proving formidable antagonists to the angler.

I wish to express my gratitude to Dr. Barnard, Assistant Director of the S.A. Museum, for his kind assistance in regard to material and literature in the S.A. Museum. Also to the Carnegie Research Fund (through the Research Grant Board of South Africa) for financial assistance.

ALBANY MUSEUM,
GRAHAMSTOWN,
August 1933.



Pteroplatea natalensis, G. and T.

1. Half-grown female, $\times \frac{1}{10}$.
2. Mature male embryo.
A. Upper dental lamina of a specimen 1830 mm. disc width.
B. Lower dental lamina of same.

Neill & Co., Ltd.

MARINE FISHES OF SEVEN GENERA NEW TO SOUTH AFRICA.

By J. L. B. Smith.

(With Plates V and VI, and one Text-figure.)

The following new genera are described below:—

Family Stromateidae, *Papyrichthys*.
Family Batrachoididae, *Batrichthys*.

Family Syngnathidae.

Microphis brachyurus Blkr.

1888. Day, Fishes of India, p. 680, pl. clxxiv, fig. 3 (*Doryichthys bleekeri* Day).

1922. Weber and de Beaufort, Indo-Aus. Fishes, iv, p. 44, fig. 21.

Body moderately slender, depth 4·5 in head, almost as wide as deep. Head 4·8 in length to caudal base. Tail (without fin) slightly shorter than half distance from snout tip to vent. Eye 10, snout 1·6, and post-orbital 3·4 in length of head.

Operculum with a slight medio-longitudinal ridge for the entire length; on one side 3, on the other 5, similar shorter, curved, radiating ridges below, all feebly serrate. Snout very compressed, with supero-median ridge. Supra-orbital ridge continuous from temporal region on to snout. All ridges on head and snout feebly serrate.

Rings 22 + 23. Each body plate has 14–18 smooth parallel vertical ridges, which sometimes become furcated and reticulate below. Across

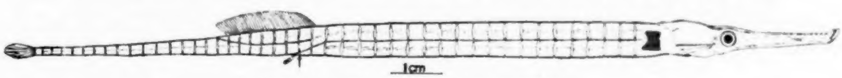


Fig. 1.—*Microphis brachyurus* Blkr.

the middle of each plate are 3 longitudinal curved ridges. The edge of each plate is serrulate, the serrae corresponding in number with the vertical ridges; last spinelet in each plate slightly enlarged.

The supero-lateral body ridge is discontinuous with the supero-lateral caudal ridge, and extends to the 7th caudal ring. The medio-lateral body

ridge curves down below the origin of the dorsal and unites with the infero-lateral caudal ridge on the 2nd caudal ring. The infero-lateral body ridge is not continuous with the infero-lateral of the caudal, and curves on to the ventral surface of the caudal, ending in the 2nd caudal ring. The supero-lateral caudal ridge curves down (forwards) below the hind end of the dorsal to medio-lateral, and extends as far as the hind margin of the last body ring.

D 40, base not raised, as long as snout, originates on penultimate body ring, on 9 rings (2 + 7).

A 5, very small, inserted below anterior dorsal rays.

P 19, slightly longer than eye, emarginate. Caudal small, about 3 in snout, rounded. No brood pouch visible, presumably a female specimen.

Colour.—Light brown, margins of plates lighter. Fins light; caudal dark.

Length.—160 mm.

A single specimen, from Durban, presented by E. C. Chubb, Esq., Curator of the Durban Museum.

M. brachyurus has been recorded from East Africa to the Indo-Pacific. The only other species of this genus hitherto recorded from Africa is *smithii* Dum., from the tropical west coast, which is stated to be fluviatile.

M. brachyurus is closely related to this species, differing only in certain minor features, such as the longer snout and the more posterior insertion of the shorter dorsal. It is possible that wider collection may show that the two forms are identical. It appears preferable to maintain the Indian Ocean form as a separate species until such time as the recorded areas may be linked up.

Family Plectorhynchidae.

Scolopsis vosmeri (Bloch.).

(Plate V, A.)

1878. Day, Fishes of India, p. 87, pl. xxiii, fig. 1.

Dorsal profile even, body compressed, ovate. Depth 2·1, length of head 2·9 in length of body: eye 3·1 in head, slightly greater than snout and than interorbital width, 1·1 in postorbital part of head. Preopercular margin concave, strongly serrulate, spinelets directed obliquely outwards. Preorbital produced backwards into a prominent flat spine, extending almost to below hind margin of pupil: 5 graduated smaller spines below. Suborbital feebly serrated. Muciferous pores on anterior part of head. Mouth small, terminal, maxilla extends to below anterior margin of eye, almost entirely concealed beneath preorbital. Villiform teeth in bands in both jaws, tapering towards the sides, which have only a single row of

teeth. Palate and tongue edentate. Gill-rakers 5, very short and stout; 3 in gill-fringes, which are 2·5 in eye.

D X 9, commences above middle of operculum, not notched. 1st spine shortest, 4·4 in head; 2nd 3·1; 3rd 2·6; 4th and 5th longest, 2·4; last 2·8 in head. Anterior rays equal to last spine.

A III 7, commences below the 2nd dorsal ray. 2nd spine very stout, longest slightly longer than 4th dorsal spine. Vertical fins not scaly.

P 18, 1·3 in head, rounded.

V I 5, 1·25 in head, inserted below 6th dorsal spine; 1st ray filamentous, reaches to base of 2nd anal spine.

Caudal forked, upper lobe longer.

Scales ctenoid, l.l. 41, ltr. 3½/14; l.l. tubes bifurcate on anterior scales. Some posterior l.l. scales have 2–3 superior branches each ending in a pore. l.l. scales smaller than body scales, 4–5 series on cheek.

Colour.—Yellow-brown, with a light band over the nape and a light stripe along the side. Dorsal dark anteriorly, other fins light; axil of pectoral and upper hind margin of operculum black.

Length.—107 mm.

Locality.—Presumably Port Alfred, having been found together with other unlabelled fishes among the old collection of the Albany Museum.

Distribution.—Indo-Pacific.

This is the first authentic record of a species of this genus from South Africa. As mentioned by Barnard (Ann. S.A. Mus., 1925, xxi, p. 669), Playfair and Gunther record *Scolopsis monogramma* K. and v. H. from Mozambique, but without citing any authority.

I have seen no recent work dealing with the species of this genus, but the older differentiation, based apparently largely upon coloration, appears none too sound, and is probably in need of revision.

The presence of this species on our southern coast is noteworthy. The stretch of coast from Algoa Bay to East London has not before received much attention from ichthyologists, and has proved a rich collecting ground. Numerous species formerly believed to be confined to the western and south-western coasts (among others *Congiopodus torvus* (Gron.) and many species of *Clinus Cuv.*) have been found commonly occurring there, while many species normally accounted as tropical (*e.g.* among others *Petroscirtes tapeinosoma* (Blkr.), *Monoceros Unicornis* (Forsk.), and *Albula vulpes* (Linn.)) have also been found.

The occurrence of the present species is therefore not in any way exceptional.

Family BROTULIDAE.

Grammonus opisthodon n. sp.

(Plate VI, B.)

Body compressed, moderately elongate, tapering uniformly from nape. Depth 4, length of head 3·2 in length of body. Eye 7, snout 4, interorbital 3·2, and postorbital 1·7 in length of head. Nostrils widely separated, anterior on snout. No barbels or spines on head, except for a strong spine, and a second, weaker, diverging on opercle. Preopercle margin below skin, with an obtuse ridge at the angle. Muciferous pores on head, very marked on chin. Snout obtuse, somewhat swollen. Mouth terminal, large, slightly oblique. Maxilla extends well behind eye, its length 1·7 in length of head, posteriorly dilated to a width equal to eye, with a retrorse spine on the hinder lower edge. A single series of fairly large curved conical teeth in each jaw: no villiform teeth. Two separate obtuse vomerine knobs, each with two large conical curved teeth. Palatines, other bones, and tongue edentate. Gill-membranes separate, free from isthmus. Gills 4, a slit behind the 4th. Gill-rakers 3, long and spinose, plus 5 spinous flattened ridges anteriorly. Pseudobranchiae absent. Branchiostegals 6. Vent postmedian.

D 65, originates 1·6 times as far from caudal base as from tip of snout, over middle of pectoral.

A 35, originates 1·5 times as far from tip of snout as from caudal base. Median fins confluent with caudal.

P 23, 1·5 in head, rounded, base enlarged.

Ventrals each reduced to a single filament, about 4 in head, inserted below the opercle.

No sign of any scales, or of lateral line.

Caudal small, pointed.

Length.—50 mm.

Locality.—Port Alfred.

Colour.—Brownish, with numerous small black spots.

This interesting small specimen is unfortunately not in very good condition, and the absence of scales and lateral line cannot therefore be regarded as established. Since it does not appear to fall into any genus of this family of which I have a description, I forwarded the specimen to Mr. Norman of the British Museum, who, at my request, compared it with the Brotulids in their collection. It is apparently identical with none of these.

I have provisionally assigned it to *Grammonus* Gill, with the diagnosis of which it agrees broadly. It differs in many features, however, the

most marked being the presence of the maxillary spine, and in the absence of villiform teeth in the jaws and on the vomer, as well as in the absence of scales and of lateral line.

Generic distinction in the Brotulidae appears to be rather fine, and the present species may well serve as the type of a new genus. This is, however, largely dependent upon the discovery of specimens in good condition, in which the presumed absence of scales and lateral line may be confirmed. This is the first record of a species of this genus from South Africa. Two other species are known, both from the Mediterranean: *ater* Risso is probably bathybial and is said to come inshore to spawn; the other is *armatus* Doederlein, about which little is known.

Family STROMATEIDAE.

Papyrichthys n.g.

Body ovate, very highly compressed, especially at the bases of the dorsal and anal fins, these regions being distinct from the body proper. Mouth large, slightly oblique. Maxilla excluded from margin of upper jaw, almost entirely concealed beneath preorbital. A single row of moderate fine-pointed teeth in each jaw. Palatal teeth present or absent. Branchiostegals 5. Gill-opening wide, membranes free, rakers well developed. Pseudobranchiae present.

Dorsal and anal very long, rays free from enveloping skin. Pectorals inserted low down. Ventrals of one short spine and five rays, longer than pectorals, inner rays longest, extending well behind origin of anal. Body and part of head covered with very small cycloid scales, probably always more than 100 in lateral series. Pores on head and body few or absent. Lateral line high, more or less following the dorsal profile. Air-bladder present. Pyloric caeca moderately numerous, branched. Vertebrae 40.

Genotype *pellucidus* Lütken.

This genus is related to *Psenes* C. and V., but it is well differentiated by the very minute scales, the size and shape of the ventrals, the very highly compressed body, and the greater number of vertebrae. I have examined a specimen of *Psenes indicus* Day, which apparently does not possess the many-branched pyloric caeca such as are found in *Papyrichthys*. This may prove a characteristic feature of this latter genus, although Regan (Ann. Mag. Nat. Hist., 1902 (7), X, p. 118) has given reasons why the nature of the caeca is not very reliable in defining genera in this family. *Psenes* is stated by Regan (*loc. cit.*) to have 25 vertebrae, but while he placed *pellucidus* in this genus, he had not seen a specimen, and merely followed Lütken's diagnosis.

The very highly compressed plastic body, and the dentition, would

indicate that *Papyrichthys* is related also to *Schedophilus* Cocco, but it is distinguished from this genus by the absence of pores on the body and of the thickened porous skin on the occiput, as well as by the course of the lateral line.

Papyrichthys pellucidus Lütken.

(Plate VI, A.)

1895. Goode and Bean, Ocean. Ichth., p. 221, pl. lxiii, fig. 228 (*Psenes pellucidus* Lütken).

1902. Regan, Ann. Mag. Nat. Hist. (7), X, p. 125 (*Psenes p.*).

Body soft and flabby, very compressed, maximum width at shoulder about 10 in length. Dorsal profile gently sloping from nape. Regions containing the dermal rays at bases of dorsal and anal fins very highly compressed, almost translucent, sharply defined. Snout very blunt, almost vertical, with slight mesethmoidal ridge.

Depth 2·8, length of head 3·0 in length of body. Eye 4·0, interorbital (convex) 5, snout 3·4, and postorbital length 2·1 in head. Interopercle with traces of marginal spinules. Other bones of head entire. Preorbital with anterior trifid ridge. Bones of head soft and cavernous. A few pores on chin and head. None on body. Nostrils close together, much nearer snout tip than eye. Mouth large, terminal, slightly oblique, jaws equal. Maxilla extends to below the anterior third of the eye; end of maxilla slightly expanded. A single comb-like row of moderate, fine, pointed teeth, slightly recurved, in each jaw; those in lower jaw slightly larger. Palatal bones edentate, but signs of small teeth on vomer. Tongue free, edentate. Gill-rakers 13, longest slightly shorter than gill-filaments, 3 in eye, not very close set, spinulate below. Pseudobranchiae well developed. Branchiostegals 5. Pyloric caeca 10, each lobate, many-branched.

D XII 34 (spines all broken, very weak), originates slightly behind preopercular margin. Anterior rays slightly shorter than mid-posterior, which are 1·7 in head. Hindmost rays slightly shorter. Bases of spines enveloped in skin; rays quite free, joined by membrane.

A 35 (or I 34), originates below the 4th soft dorsal ray. Shape similar to dorsal; hinder rays of same length as corresponding dorsal rays. Rays free from skin.

P 19, inserted low down, base slightly oblique. Fin rounded, 1·4 in head.

Ventrals I 5, inserted below the pectoral base, 1·3 in head, inner rays longest, reach to the base of the 5th anal ray.

Caudal damaged (forked according to G. and B., *loc. cit.*), 10 + 16 + 10. Peduncle longer than deep, expanded posteriorly.

Scales cycloid, very small, over whole body. Head apparently naked, but damaged. (On cheek, according to G. and B.'s fig., *loc. cit.*) Lateral line ascends to run parallel with dorsal profile, almost an eye-diameter below. l.l. about 125 (very approximately; G. and B.'s fig. shows 150).

Colour (preserved).—Uniform light brown. Fins light; dorsal, anal, and ventrals with darkish margin.

Length.—120 mm.

A single specimen from Durban, presented by E. C. Chubb, Esq., Curator of the Durban Museum.

There appears to be very little doubt that the present specimen should be assigned to *pellucidus*.

The specimen is not in very good condition, but most of the features may be discerned.

G. and B.'s figure shows a deeper body, more scales, a shorter snout, and the outer ventral rays longer than the inner. These differences are not significant, and may be due to the difficulty of observing accurately in so small a specimen as the type (about 60 mm. total length).

This species has been recorded from the Atlantic (32° N. × 76° W.) from a depth of 528 fathoms, and its presence in Natal waters is of interest.

Schedophilus medusophagus Cocco.

(Plate V, C.)

1876. Gunther, Challenger Rep., xxii, p. 46.

1895. Goode and Bean, Ocean Ichth., p. 214, fig. 223.

1902. Regan, Ann. Mag. Nat. Hist. (7), X, p. 196 (*Lirus m.*).

Body very compressed, ovate, extremely soft and pliable. Regions at bases of dorsal and anal, containing dermal rays, distinct and differentiated. Dorsal profile evenly convex. Snout slightly swollen, somewhat blunt. Interorbital strongly convex.

Depth 2·6, length of head 3·9 in length of body. Eye equal to snout and to interorbital width, 4·6, postorbital length 1·8, in length of head. Preorbital depth 1·7 in eye. Preopercle with flat spinules round angle. Traces of spines on interopercle. Remaining bones entire. Occiput and snout with thickened porous integument. Almost whole of head except operculum densely pitted with pores: radiating series round orbit. Nostrils close together, midway between snout tip and anterior margin of eye.

Gill-openings wide, membranes free. Rakers fairly long, 15 on lower part of anterior arch, longest slightly shorter than gill-filaments, 2 in eye. Rakers spinulose on basal half. Oesophagus with 14 papillate sacs. Vertebrae 42 (16 + 26).

Mouth large, slightly oblique; jaws equal. Maxilla extends to below behind centre of eye: upper margin slips, for the whole length, beneath the preorbital. Supplemental bone not obvious, maxilla not, or scarcely, expanded posteriorly. Teeth in a single comb-like series in each jaw, larger and smaller teeth alternating, larger teeth subspatulate. Palate and tongue edentate.

D 52, commences above hind margin of head. First few rays appear spinate, but all but tip is hidden in scaly skinny sheath. Rays increase gradually in length to the middle of the fin; there about 3 in head, remain subequal to the posterior, which are slightly shorter. The whole of the fin with a scaly, skinny basal investment; longest rays emerge for less than half of their length. Fin low, rays inclined obliquely backward, apparently not fully erectile.

A 35, commences below the 20th dorsal ray; shape of fin, length of rays, and skinny basal investment as for dorsal.

P 20, inserted very low, 2·2 in head, base not oblique. A scaly, skinny investment almost half of length of fin. Upper rays longer.

V I 5, inserted very slightly in advance of the pectorals, 3 in head. Last ray joined to belly by a membrane. Base of fin in scaly, skinny investment.

Caudal gently rounded, 1·7 in head. Peduncle as deep as long. Scales cycloid, fairly small. l.l. 135, very slightly curved anteriorly, becomes straight below the 12th dorsal ray, running obliquely down to peduncle. Whole of body and head, except interorbital and chin, scaly. A pore below almost every scale on body.

Colour.—Uniform brown (preserved).

Length.—230 mm.

A single specimen, found among fishes collected by S.S. "Pickle," labelled "Natal Fishes," unclassified, presented by the Director of the Government Fisheries Survey to the Albany Museum.

Regan (*loc. cit.*) regards *Schedophilus* Cocco as a synonym of *Lirus* Lowe, and states that *Lirus* has 25 vertebrae and a small supramaxilla. There is no doubt that the two genera are closely related, but the greater number of vertebrae of *Schedophilus*, as well as other minor features, would appear to justify the maintenance of this genus as distinct from *Lirus*. Meristic variation is alone of doubtful validity in defining genera, but since the other species of *Lirus* all presumably have 25 vertebrae, it would appear reasonable in this case. Further, I can find no signs of any supramaxilla in my specimen, nor is any mentioned in any description, or shown in any figure of *medusophagus* to which I have access.

It is with considerable doubt that the present specimen is assigned to *medusophagus*, since it differs in many significant features. The heavy dermal investment of the greater part of the dorsal and anal, as well as the

similar partial investment of the pectorals and ventrals, is not mentioned in descriptions of that species. Günther (*fide* G. and B., *loc. cit.*) states that the hinder dorsal and anal rays are not "erectile into the vertical position." This is true of my specimen, but the reason for this is the skinny sheath. Further, both dorsal and anal are longer, and there are more rays in the present specimen, but *medusophagus* is stated to vary widely in these counts, so that the present differences may not be of specific significance.

medusophagus has been recorded from the Atlantic and from Samoa. Its presence in Natal waters is of interest.

Family Scorpaenidae.

Setarches güntheri Johnson.

(Plate VI, C.)

1876. Günther, Challenger Rep., xxii, p. 19, pl. i, C (*fidjiensis*); p. 19 (*parmatus*).

1895. Goode and Bean, Ocean. Ichth., p. 263; p. 264, fig. 249 (*parmatus*).

Body moderately compressed, greatest width at nape. Head fairly depressed, interorbital almost plane. Depth 3·1, length of head 2·3 in length of body. Eye 6, snout 2·4, interorbital 4·5, and postorbital 2 in length of head. Head ridged and spinose. Preopercular stay prominent. Two long diverging spines on opercle. Suprascapula and coracoid exposed, each terminating in a flat spine. Three spines at angle of preopercle, slightly less than eye, the upper two on one side almost parallel (Pl. VI, A), the lower diverging: on the other side the three are equally divergent. Two others on lower margin, anterior smaller. Three preorbital spines projecting downwards over the maxilla. The anterior small and antrorse; the other two retrorse, graduated, the posterior the longer. Two low, flattened occipital spines, one similar postorbital spine, on each side, One antorbital spine projecting back over the eye, and one small retrorse nasal spine. Mouth large, somewhat oblique, maxilla highly expanded posteriorly, extends to below hind margin of orbit. Jaws subequal, no marked bony tubercle at symphysis of lower jaw. Upper jaw notched opposite symphysis. A narrow band of villiform teeth in each jaw. A chevron-shaped band, discontinuous at apex, of similar teeth on vomer. Similar teeth on palatines. The premaxilla has a supero-median expansion which slides under the maxilla. Premaxillary process short and curved. Nostrils tubular, close together, nearer anterior margin of eye than snout tip. Gill-openings wide, membranes free. Branchiostegals seven. Pseudobranchiae present. Gill-rakers long, slender, 10 on lower part of anterior arch, anterior longest, almost equal to eye: gill-filaments short, about 3 in eye.

D XII 10, originates slightly in advance of hind margin of head. 1st spine equal to eye, then increase to the 4th, which is longest, 2·6 in head: thereafter decrease to the 11th, which is 6 in head. 12th spine more than twice 11th. Soft dorsal rounded, midrays longest, almost 2 in head.

A III 5, originates below the 3rd dorsal ray.

P 22, 1·3 in head, base fairly broad, extends to below the 4th dorsal ray. The upper ray and on one side 3, and on the other the 4 lower rays simple, the remainder branched. Ventrals 1·9 in head, do not reach vent; 1st ray longest.

Caudal almost truncate, 1·1 in head. Peduncle compressed, as deep as long, equal to eye.

Scales minute, cycloid. About 95 in lateral series. Lateral line raised, 26–27 perforations. Opercle and preopercle (above and below suborbital ridge) scaly. Rest of head naked.

Colour.—Light red-brown. Fins light.

Length.—190 mm.

Locality.—Presumably Natal, being found among fishes labelled "Natal Fishes," unclassified. Collected by S.S. "Pickle"; presented to the Albany Museum by the Director of the Government Fisheries Survey.

The three nominal species of this genus differ from one another only in unimportant details, and the types vary considerably in size. The type of *guentheri*, from Madeira, is 9 inches long; of *fidjiensis*, from the Fijis (315 fms.), 3 inches; while the type of *parmatus*, from New England (180 fms.), is only 2 inches in length, besides being damaged.

The spination of the cephalic bones is evidently variable. In my specimen the arrangement of the preopercular spines is on one side intermediate between the arrangement on the other and the arrangement in *güntheri*, in which they are stated to be parallel. The anterior (3rd) preorbital spine is not much exposed, and may not be obvious in the other specimens, especially in the smaller.

The differences in depth of body and in the relative sizes of the fins of the various species described can be explained by the difference in size between the specimens, and cannot be regarded as of specific significance.

Bathybial species are usually cosmopolitan, and the presence of this species in Natal waters, while of interest, is not in any way exceptional.

Family Batrachoididae.

Batrichthys n.g.

Three lateral lines, each pore with minute cutaneous appendage above and below; middle line obscure. Jaws with tapering bands of small conical teeth. Larger teeth on vomer and palatines. Opercle with 2

spines. Subopercle with 2 spines; lower shorter, parallel or slightly divergent. Gill-opening fairly wide, extending from above the axil to below pectoral base. Gill-rakers few, short, obtuse or tubercular. Pharyngeal teeth equal or graduated in size. Three dorsal spines. Caudal free. No axillary foramen. Interorbital almost plane. Frontal ridges feeble. Vertebrae 29.

Genotype *albofasciatus* n. sp.

This genus is closely related to *Coryzichthys* Ogilby (from the Indo-Australian area), which is stated to have very restricted gill-openings, embracing only the upper half of the pectoral base, and the pharyngeal teeth are unequal in size. Ogilby (Ann. Queens. Mus., 1908, No. 9) * places *gangene* Ham-Buch. in *Coryzichthys*, despite the fact that Day's figure (Fishes of India, p. 269, pl. lx, fig. 1) shows this species to have gill-opening at least as large as the pectoral base. Day's figure (which is named *grunniens*, probably in error) shows 5 ventral rays, which must be erroneous, and he neither described nor figured any lateral line system.

There appears to be little doubt that *gangene* and the species described below are congeneric.

This genus differs considerably from the two genera, *Batrachoides* Lac. and *Marcgravia* Jord., the only two hitherto found in South Africa.

Batrichthys albofasciatus n. sp.

(Plate V, B.)

Body robust, compressed behind. Head depressed, interorbital flat, skin slightly rugose. Depth 5·1, length of head 3 in length of body. Eye 5·5, snout 4, interorbital width 3·7, length of postorbital 1·6 in length of head. Six small barbels, about $\frac{1}{4}$ eye, on each side of chin, and one at hind end of maxilla, and one at each side of upper jaw opposite symphysis. Conspicuous mucus pores on head, each with a minute cutaneous appendage above. Two short fimbriate nasal tentacles. No supra-orbital tentacles. Mouth large, maxilla extends to below posterior margin of orbit. Small curved conical teeth in posteriorly tapering bands in both jaws. Six larger conical teeth across vomer, with 4 widely-spaced smaller teeth anteriorly. A single series of similar teeth on palatines. Pharyngeal teeth curved, conical, of uniform size on upper; posterior teeth on lower pharyngeals slightly larger than anterior, no marked inequality in size. Gill-membranes fused with isthmus, membrane expanded, fused with chest to below behind pectoral base. Gill-opening wider than the whole width of the pectoral base. Branchiostegals 5. Gill-rakers short, tubercular,

* I have not seen this paper.

apically dilated or bifurcated, 8 on lower part of anterior arch. Two acute opercular spines, upper larger, divergent. Two similar on suboperele, upper larger, almost parallel. Vertebrae 29 (12 + 17).

D III + 19, A 14. Soft dorsal and anal rays increase in length posteriorly, hind rays 2·5 in head.

P 18, 1·5 in head, base heavy, sublobate. No foramen.

Ventral 1·5 in head; spine in thickened skin.

Caudal rounded, 1·4 in head.

No scales. Three lateral lines. Upper and lower distinct, middle obscure, consisting each of a row of pores, each with a minute cutaneous appendage above and below. Upper runs from opercular margin up to the soft dorsal and along the base of the latter. The middle line curves down from the same origin as upper and runs along the middle of the side, becomes obsolete before anal origin. The lower runs from the lower margin of the pectoral base down to the origin of the anal, and then along the base of the latter.

Colour.—Brown, irregularly mottled with darker, and with dark spots on the body, head, and all fins. Five slightly sinuous white cross-bars, hinder 4 extending on to soft dorsal.

Length.—120 mm.

Locality.—Great Fish Point.

Type.—In the Albany Museum.

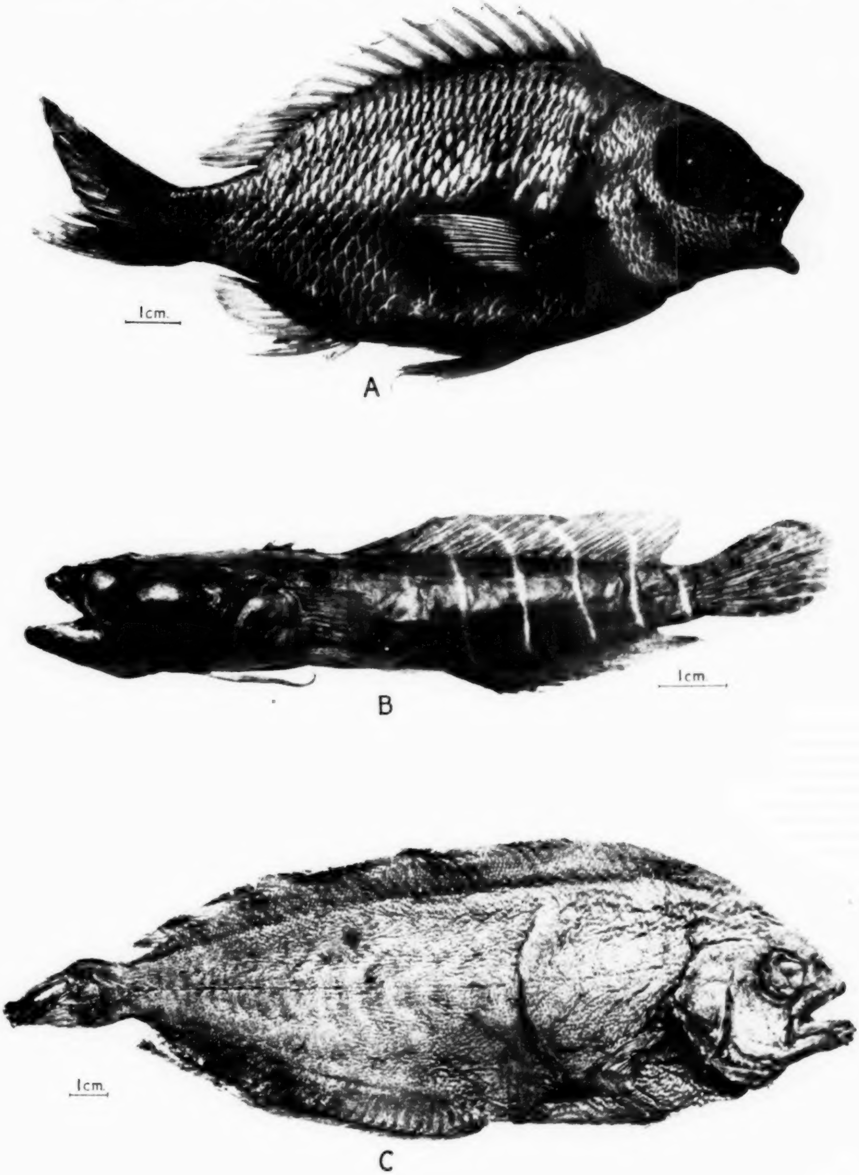
As indicated above, it is open to doubt whether this species should not be assigned to *Coryzichthys* Ogilby. The specimen described above is evidently bathybial, since it was thrown up after a storm at Great Fish Point, and the distended air-bladder was found to have filled almost the whole mouth.

While bathybial forms are generally more or less cosmopolitan, it appears preferable to retain this new genus until such time as the opportunity occurs to compare the genotype with Indian or Australian species.

albofasciatus is very closely related to *gangene*, differing in fin formulae, in certain dimensional relationships, and in the absence of supra-orbital tentacles. This latter difference may prove to be sexual, and it is not unlikely that the two may prove to be conspecific.

I wish to express my gratitude to Dr. Barnard, Assistant Director of the South African Museum, for his kind assistance and for the loan of literature. Also to the Carnegie Research Fund (through the Research Grant Board of South Africa) for financial assistance.

ALBANY MUSEUM,
GRAHAMSTOWN,
October 1933.



A. *Scolopsis vosmeri* (Bloch.).
B. *Batrichthys albofasciatus* n.g. et sp.
C. *Schedophilus medusophagus* Cocco.

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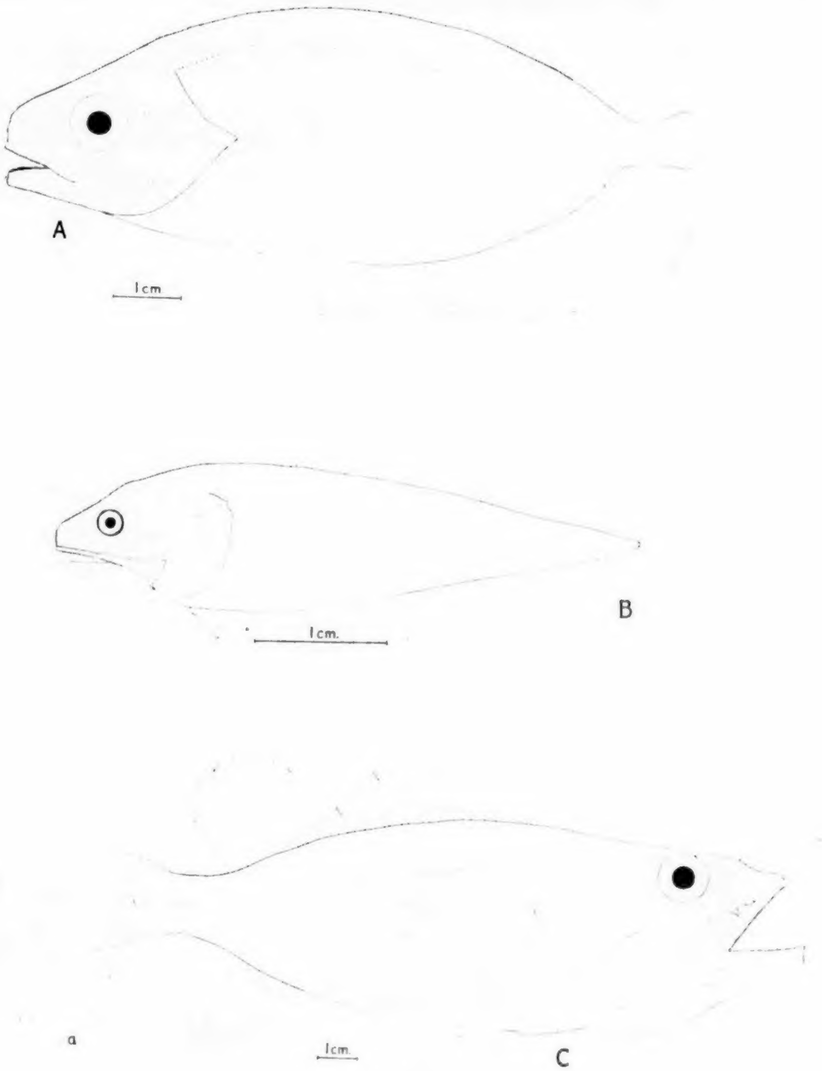

A. *Papyrichthys pellucidus* Lütken n.g.
B. *Grammonus opisthodon* n. sp.
C. *Setarches güntheri* Johnson.
a, Preopercular spines on left side.

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OBITUARY.

SIR THOMAS MUIR, M.A., LL.D., D.Sc., F.R.S., C.M.G.

Sir Thomas Muir was born on 25th August 1844 in Lanarkshire, Scotland, and died at Rondebosch, Cape Town, on 21st March 1934.

In 1868 he graduated M.A. at the University of Glasgow, and from then to 1871 he was mathematical tutor in College Hall, St. Andrews. From 1871 to 1874 he was assistant to the Professor of Mathematics in the University of Glasgow, and from 1874 to 1892 head of the Mathematics and Science Department of the High School, Glasgow.

In 1892 he came to Cape Town, and from then to 1915 he was Superintendent-General of Education for the Cape. On retiring from that post he received the honour of knighthood. He had been made C.M.G. in 1901.

In 1884 he received the degree of LL.D. from the University of Glasgow, and in 1921 he was the first recipient of the honorary degree of D.Sc. from the University of Cape Town, which had been founded in 1918. From 1897 to 1901 he was Vice-Chancellor of the University of the Cape of Good Hope.

The Royal Society of Edinburgh, of which he was a fellow from 1874, conferred on him the Keith Medal and Prize in 1884, and again in 1899; also the Gunning Victoria Jubilee Prize in 1916.

In 1900 he was elected F.R.S. He joined the S.A. Philosophical Society in 1892, was its President from 1895 to 1897, and was on the Council for nine years. He was a foundation member of the Royal Society of South Africa. In 1910 he was President of the South African Association for the Advancement of Science.

Sir Thomas was a Trustee of the South African Public Library from 1893 to 1928, and Chairman of the Board of Trustees from 1906 to 1924. From 1893 he was a Trustee of the South African Museum, and was Chairman of the Board of Trustees from 1930 to his death.

He began to publish mathematical papers in 1872; in 1874 he wrote on "Continuants, a new Special Class of Determinants," and from then he took up as his life work in mathematics the history and theory of determinants. In all he wrote about three hundred papers; two of his latest are published in the Transactions of the Royal Society of South Africa (vol. xxii, pt. 1, 1934). He contributed over fifty papers to the S.A. Philosophical Society and the Royal Society of South Africa.

Of his great work, "The Theory of Determinants in the Historical Order of Development," five volumes have been published, vol. i in 1906 and vol. v in 1930, and some material for vol. vi is in manuscript, most of the papers published since 1930 on determinants having been classified and analysed by him in the same way as was done in the published volumes.

Sir Thomas has laid South Africa under a deep debt of gratitude by bequeathing to the South African Public Library his mathematical books and pamphlets: with it Cape Town now possesses, in addition to valuable books, a collection of mathematical serials second to none in the British Empire except those of the University of Cambridge and the British Museum.

LAWRENCE CRAWFORD.

SULPHUR AS A FACTOR IN THE CORROSION OF IRON AND STEEL STRUCTURES IN THE SEA.

By W. J. Copenhagen.

Read September 21, 1932.

(With seven Text-figures.)

The present knowledge of the facts concerning the corrosion of iron and steel in aqueous solutions of alkali chlorides serves as a basis.

Surface Films.—The existence of films on metal surfaces has been observed by many workers. Speller * and Evans †, in their textbooks on corrosion stress the importance of protective films. The composition, stability, and protection afforded by these films has been the subject of much investigation and research.

Evans ‡ isolated a film responsible for the passivity of an iron anode in acid solution. Cox and Roetheli § contend that at low oxygen concentrations the corrosion product formed is composed primarily of a porous black magnetic oxide of iron. At high oxygen concentrations the corrosion product is predominantly a red, gelatinous, ferric hydroxide. In a previous paper by Forrest, Roetheli, and Brown || it was shown that granular magnetic oxide is not very resistant to the diffusion of various ions and oxygen. Gelatinous ferric hydroxide is, however, more resistant and greatly retards the diffusion of ions and oxygen.

The Mechanism of the Corrosion of Iron and Steel in the Sea.—The composition of sea water is fairly uniform. Slight variations occur in the salinity, temperature, pH, nutrient salts, carbonate and oxygen content, depending on the locality and season. The variation in salinity and temperature affects the oxygen concentration—this being by far the most important factor from a corrosion standpoint.

* Speller, Corrosion, Causes and Prevention. McGraw-Hill, 1926.

† Evans, Corrosion of Metals. Arnold, 1926.

‡ Evans, "Isolation of the Film responsible for the Passivity of an Iron Anode in Acid Solution," Nature, 26th July 1930.

§ Cox and Roetheli, "Effect of Oxygen Concentration on Corrosion Rates of Steel, and Composition of Corrosion Products formed in Oxygenated Water," Journ. Ind. Eng. Chemistry, vol. xxiii, No. 9, p. 1013.

|| Forrest, Roetheli, and Brown, Journ. Ind. Eng. Chemistry, vol. xxiii, No. 6, p. 650, June 1931.

The cations present in greatest concentration are carbonate, 4 per cent.; chlorine, 2 per cent.; and sulphate (calculated as sulphur), 0·1 per cent. (approximate figures), and there is sufficient excess base to give a reaction of a pH approximately 8.

Cushman * has shown, by means of his "ferroxyl" indicator, the existence of anodic and cathodic areas in any piece of iron and steel. Evans † has shown that these areas are due to the distribution of oxygen. Oxides or iron, phosphorus, sulphur, and carbon do tend to act as cathodes, but the oxygen distribution is far more important.

When iron or steel is immersed in sea water it is observed that a thin, greenish-white precipitate appears to stream away from the metal, and after a while the surface becomes covered with a thin brown film. The iron probably first enters solution as ferrous chloride from the anodic areas, and a soluble cathodic product is formed, *i.e.* sodium hydroxide.

At the pH of sea water the sparingly soluble ferrous hydroxide is instantly precipitated. In the presence of the dissolved oxygen, however, the ferrous hydroxide is oxidised to ferric hydroxide. This gradually builds up a film, commencing at the anodic areas, until afterwards the whole of the portion of the immersed metal is covered with a red, gelatinous film. This film, although acting in a protective capacity, is not impervious to ions, especially chlorine (Britton and Evans ‡), and also to sulphate ions.

There is a reason for believing that this film is not in direct contact with the metal, but that it is precipitated a sensible distance away from it (Evans and others).§

The corrosion of the iron now proceeds through this outer layer. Evans ‖ discusses the possibilities of this outside layer acting as a loose diaphragm or membrane. This diaphragm will shield the metal from direct contact of oxygen, and thus stimulate the continuance of the anodic attack. Soluble ferrous salts will be formed inside the membrane, and their precipitation will take place *outside* in the main solution.

The possibility of a difference in the composition of the solution in direct contact with the surface of the metal, and that of the main solution is a factor mentioned by Whitman and Russel.¶ Corrosion would not be able to continue were it not for the removal of the polarising or insulating film of hydrogen deposited on the surface of the metal.

* Cushman, Journ. American Electrochemical Society, 1909.

† Evans, Textbook (see "Key" experiment in textbook).

‡ Britton and Evans, "The Passivity of Metals: Part VI," Journ. Chem. Soc., p. 1773, 1930.

§ Evans, Bannister, and Britton, "The Velocity of Corrosion from an Electrochemical Standpoint," Proc. Royal Soc., p. 355 A, vol. 131, 1931.

‖ U. R. Evans, Journ. Soc. Chem. Ind., 315 T., vol. lxiii, No. 44, October 1924.

¶ Whitman and Russel, Journ. Soc. Chem. Ind., 193 T., vol. lxiii, No. 26, June 1924.

This is accomplished by the dissolved oxygen present in the water combining with the atomic hydrogen to form water, and also by the atomic hydrogen being converted into molecular hydrogen, Walker.*

Over-voltage also plays a part here, and the text-books on corrosion indicate the significance of this factor. Carbon dioxide and magnesium salts undoubtedly play important parts, but it is considered that their action is subsidiary to the principal reaction.

In brief, iron in contact with sea water produces soluble ferrous salts. These ferrous salts are instantly converted into ferrous hydroxide. This in turn is oxidised to ferric hydroxide. The latter forms a mantle or membrane. Inside this membrane the iron effects solution. The iron solution diffuses through, and is precipitated *outside* the membrane.

Potential of Metal.—The rate at which the iron ions pass into the surrounding medium is a measure of the effectiveness of the protective films. This rate would be reflected in the potential-time curves.

The film potential method of measuring corrosion was originated by L. H. Callendar,† and was developed (with improved technique) by R. May.‡ The seventh report to the Corrosion Research Committee also makes reference.§ U. R. Evans and others || also indicate the importance of the value of the film potential.

A rising potential under certain conditions indicates that weak points in the protective film are being repaired, and a falling potential that the breakdown is extending. It is further contended that high final potentials denote immunity from attack, a middle value slight rusting, and a low, profuse rusting.

In order to obtain some idea of the magnitude of the potential attained, experiments were now conducted under actual working conditions, *i.e.* ships and jetties in the sea.

Procedure.—The potential of the structure, vessel, or specimen was determined by means of a potentiometer and a millivoltmeter. The potentiometric method was similar to that usually used in hydrogen ion concentration measurements.

The galvanometer had a sensitivity of $\frac{1}{3} \times 10^{-6}$ amp. per div., and the millivoltmeter was standardised by the General Electric Co., Schenectady, New York, U.S.A. Two types of calomel cells were employed, which were

* W. H. Walker, see Speller's book, "Corrosion, Causes and Prevention."

† L. H. Callendar, Proc. Royal Soc., A, 115, 344, 1927.

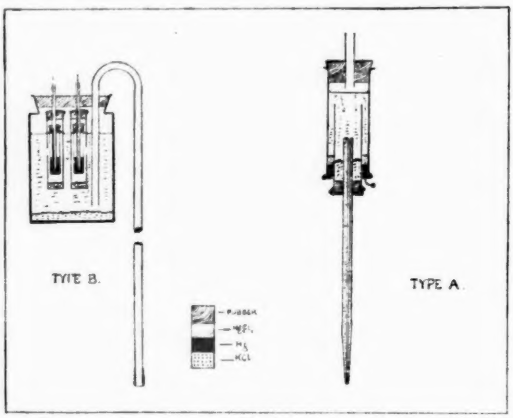
‡ R. May, Journ. Inst. Metals, vol. lx, p. 141, 1928.

§ The Seventh Report to the Corrosion Research Committee (Journ. Inst. Metals, vol. xxxii, p. 81, 1925), *ex* Nature, 17th November 1928.

|| L. C. Bannister and U. R. Evans, "The Passivity of Metals: Part V, The Potential-Time Curves of some Iron Alloys," Journ. Chem. Soc., June 1930.

slightly different from the usual standard type. Type A (see sketch) was used in most of the laboratory experiments, and type B was used in connection with the experiments actually conducted in the sea. Type A, calomel cell, was useful in being extremely portable, and also presenting a contact point of about 3 mm. Type B, calomel cell, being made of thick glass, was robust, and thus easily withstood a great amount of transportation and handling.

Both of the above types of calomel cells were constantly checked against the standard type of calomel cell and found to be in agreement. In the measurement of potentials it was assumed that the potential of the saturated KCl-calomel electrode was $+0{\cdot}250$ volts at a range from 18–20° C. This figure was deducted from all observed values.



CALOMEL ELECTRODES.

Type A, Calomel Cell.—This calomel electrode consists essentially of three concentric glass tubes, held in position by rubber stoppers. The mercury and calomel are placed in the outer tube. KCl crystals are placed in the inner. The diameter of the wide tube is 2 cm., and the total length of the electrode is about 26 cm. Contact is established by means of a platinum wire that pierces the rubber stopper as shown in the sketch. The long thin tube is a piece of barometer tubing, and is filled with saturated KCl-agar-agar. In the event of this becoming contaminated or discoloured, a fresh portion of KCl-agar-agar can be forced down the tube by applying slight pressure of air at the top of the electrode. It can be easily clamped or suspended in the solution under observation.

Type B, Calomel Cell.—This electrode has a side tube of about 80 cm. long. The side tube is filled with saturated KCl-agar-agar, and a piece

of coarse silk, as used for sieving purposes, is attached to the tip. This prevents the entire column of jelly siphoning over. When not in use this side tube was inserted in a glass tube containing saturated KCl. The calomel cells consist essentially of specimen tubes, 12 mm. (inner tube), containing the mercury and calomel, and the wide tube was about 20 mm. diameter. In both these tubes there is a hole blown in the side (see sketch). Contact is established with the mercury with a long glass tube containing a platinum wire fused through a closed end. A length of "flexible" electric wire was soldered to the platinum wire. A piece of light cord was attached to the neck of the containing jar, so that the electrode could be lowered from the deck of a vessel until a portion of the side tube was immersed in the sea.

The Potential Values of Iron and Steel Vessels and Structures.—The vessels that were examined were of different types. Observations were conducted, for the most part, at the Cape Town Docks on vessels alongside concrete wharves. Vessels were also examined lying at anchor in Table Bay, and also at H.M. Naval Dockyard, Simonstown. Although the vessels were coated with paint this did not entirely prevent access of the metal to water, Stanley.*

Electrical connection was established, as far as possible, on some integral portion of the hull. Connections were usually established, for preference, direct on to a plate constituting the "topsides." For this purpose a dry spot was chosen, and about a square inch of paint was removed and the bare metal exposed. Here contact clips were fastened. Brass scuttles or pipes were avoided. Particular care was also taken regarding the contact clips to avoid dampness or moisture between the surface of the clips and the contact point on the hull.

The large calomel electrode (type B) was lowered from the side of the vessel (or steel wharf) until the siphon tube was immersed in the sea to a depth of about nine inches. Potentiometric readings were now taken in the usual manner. Duplicate readings were made with the second cell as a control. Values were seldom found to differ more than one millivolt.

For the purpose of convenience the vessels were divided into two classes, A and B.

"A" class comprises vessels where it was known that the under water portion of the hull was composed entirely of iron or steel. In this class was also included a steel jetty.

"B" class comprises vessels where it was known that bronze propellors and zinc protector plates were fitted.

"*A*" *Class.*—It was considered that iron and steel barges, having no

* Stanley, "Electrical Conductivity of Immersed Paint Films," S.A. Journ. Sci., vol. xxv, p. 111, December 1928.

means of propulsion, would be the most suitable. These are given in Table A 1. Vessels that were known to be fitted with iron or steel propellors and possessed no brass or copper under water fittings comprise Table A 2. In Table A 3 is found the value for a steel jetty.

TABLE A 1.

The particulars regarding these craft are as follows:—

1. Hopper Barge.	No name. Particulars of painting unknown. 10 readings taken.	Mean value	−0·385 volts.
2. ,, ,,	Steel, 1. Four months since dry docking. 1 A.C. + 1 A.F. 8 readings taken.	,, ,,	−0·389 ,,
3. Small Barge.	Not dry docked for at least one year. 7 readings taken.	,, ,,	−0·375 ,,
4. Hopper Barge.	Iron, E. Seven months since dry docking. 1 A.C + 1 A.F. 24 readings taken.	,, ,,	−0·404 ,,
5. ,, ,,	Iron, D. Two months since dry docking. 1 A.C. + 1 A.F. 7 readings taken.	,, ,,	−0·391 ,,

Note.—1 A.C. = one coat of anti-corrosive paint applied when dry docked.
1 A.F. = one coat of anti-fouling paint applied when dry docked.

The above vessels were all lying at anchor in Table Bay.

TABLE A 2.

1. *Seville*, floating whaling factory. For at least six months in the Antarctic. Sides appeared very rusty. Further particulars not known. (Steel.) 8 readings taken.	Mean value	−0·367 volts.
2. *Paulus* (steel), bucket dredger, built in 1919. Six months since dry docked. 1 A.C. + 1 A.F. 4 readings taken.	,, ,,	−0·371 ,,
3. *Clara* (steel). Built in 1898. Six months since dry docked. 21 readings taken.	,, ,,	−0·363 ,,
4. *Immortelle*, minesweeper, H.M.S.A.S. Particulars not known. 7 readings taken.	,, ,,	−0·368 ,,

The mean value for this class is −0·367.

TABLE A 3.

Here a number of observations were made on a jetty, *i.e.* the collier jetty in the Cape Town Docks. This jetty has a concrete floor supported by steel girders. The girders that are immersed in the sea have, in the course of many years, become heavily incrusted with corrosion products

and also with marine growths. The exposed part of the jetty is also corroded in parts. As far as can be ascertained, this structure has not been painted (the under water part) for at least fifteen years.

Mean value—18 readings (variation −0·370 − 0·374), −0·371.

"*B*" *Class*.—The particulars of these vessels are as follows:—

1.	*J. W. Sauer*, tug. Cape Town Docks. (Steel.) Built in 1915. Phosphor bronze propellor. Zinc slabs fitted on hull and rudder. Approximately five months since dry docking. 2 readings.	Mean value	−0·380	volts.
2.	*Ludwig Wiener*, tug. Cape Town Docks. (Steel.) Built 1913. Manganese bronze propellor. Five months since dry docking. 4 readings.	,, ,,	−0·365	,,
3.	H.M.S. *Calcutta*. Cape Town Docks. Bronze propellor. Zinc on rudder. Six weeks since dry docking. 28 readings.	,, ,,	−0·390	,,
4.	H.M.S.A.S. *Protea*. Cape Town Docks. Bronze propellor. Zinc on rudder. 16 readings.	,, ,,	−0·387	,,
5.	Norwegian whaler *Foyn*. Cape Town Docks. Rusty sides. 10 readings.	,, ,,	−0·365	,,
6.	R.R.S. *Discovery II*. Cape Town Docks. New ship, six months since launched. 38 readings.	,, ,,	−0·360	,,
7.	H.M.S. *Verbena*. Simonstown Docks. Details not known. 9 readings.	,, ,,	−0·374	,,
8.	H.M.S.A.S. *Protea*. Simonstown. After cruise up West Coast. 12 readings.	,, ,,	−0·368	,,
9*a*.	*J. W. Sauer*, tug. Cape Town Docks. 1 reading.	,, ,,	−0·370	,,
9*b*.	*J. W. Sauer*, tug. Cape Town Docks. Under weigh. 3 readings.	,, ,,	−0·360	,,
10.	H.M.S. *Cyclamen*. Simonstown. 9 readings.	,, ,,	−0·401	,,
11.	R.R.S. *Discovery II*. Simonstown. (After dry docking and painting.) 12 readings.	,, ,,	−0·379	,,

The mean value of the twenty iron and steel vessels and one steel structure in the A and B classes is −0·377 volts, with a standard deviation of 0·0126. This gives a standard error of ±0·0028 volts. This figure represents the value obtained under ordinary natural conditions. When the movement is increased the potential value decreases, and if all movement is arrested the potential probably increases. The limitations of this definition of natural conditions is the movement of sea water in the dock due to tides, and also includes the movements of vessels riding at anchor to moderate winds and seas in a sheltered bay.

In this definition are also understood movements on the part of vessels

up to about one knot. When the vessel moves through the water at slow speeds (2–3 knots) the potential is found to decrease by about 10 millivolts (see B class, experiment 9*b*).

Observation conducted on board of H.M.S.A.S. *Immortelle* showed a decrease of about 30 millivolts (*i.e.* a drop from −0·370 to −0·340 volts), when the potential was determined immediately the ship was stopped after a run of six hours at eight knots. The effect of speed on the film and on the consequent variation of the potential is being further investigated.

Vessels that had been lying in the Cape Town Docks for a considerable period (five months) were not significantly different from the mean value.

Time-Potential Values of a Ship after Cleaning and Painting.—(Values from three different vessels were obtained. Below, one example is given.)

The steam trawler *Star of the South* was hauled up out of the water on the patent slip on the 21st October 1931. During the twenty-four hours that she was out of the water the cleaning and painting was completed. The vessel was built in 1903. In 1923–24 she was practically completely replated (steel plate).

11.27	a.m.	Vessel hauled down to the water.			
11.27½	,,	Water up to the keel.			
11.28	,,	Vessel began to float (zero time).			
11.29	,,	Floating.	Potential	−0·235	volts.
11.29½	,,	,, ...	,,	−0·245	,,
11.30½	,,	,, (Moving slowly.) .	,,	−0·245	,,
11.31½	,,	,, ...	,,	−0·249	,,
11.35	,,	,, (Now fastened up.)	,,	−0·250	,,
11.40	,,	,, ...	,,	−0·260	,,
12.0	,,	,, ...	,,	−0·277	,,
1.16	p.m.	,, ...	,,	−0·300	,,
29	hours later	(from zero time)	,,	−0·347	,,
53	,,	,, ,, ...	,,	−0·356	,,
70	,,	,, ,, ...	,,	−0·363	,,

As this vessel proceeded to sea no further observations were possible. About ten days later readings were taken, and a value of −0·380 was observed.

This vessel was painted with the usual coatings of anti-corrosive and anti-fouling paint.

As the sides and bottoms of ships are usually either covered with paint or marine growths it is not possible to observe directly the nature or the colour of the film. Whatever the nature of this film may be, it must be extremely uniform in composition. Furthermore, the composition of this film is influenced only very slightly (if at all):

1. When it is formed on iron plates (as used in ship building).
2. When it is formed on steel plates (as used in ship building).

3. By small quantities of adventitious elements such as carbon, phosphorous silicon, as may be found in commercial steel and iron plates.

Attention must be directed to the variation in the individual values of the vessels of the "B" class. Here, in the case of No. 3, the difference between the reading at the bow and at the stern is of the order of 40 millivolts. From figures obtained in H.M.S. *Verbena* there was a difference of 50 millivolts between these points. Some of the other vessels in this class likewise show variations, while others definitely do not.

The potential value of iron when in electrical contact with copper depends on the relative areas of the two metals. In the case of ships of the "B" class, on this assumption it would depend on the relative areas of a trimetallic system as iron, bronze, and zinc are present. Attempts were now made with regard to the possibility of reproducing this constant potential. Experiments with this objective in view were therefore conducted.

The Time-Potential Curve of Iron and Steel in Sea Water.—Iron or steel specimens, varying in size and shape, details of which will be found in the experiments described, were used for these experiments. Except where stated, the specimens were, for the most part, employed just as received from the local foundry. The specimens were usually cuttings from steel plate or wrought iron bars, and had received no treatment (acid, paint) apart from casually dislodging loose scale. The metal was clamped or supported by the usual laboratory clamps, and placed in position in large glass containers having a capacity of about two litres. Fresh samples of sea water were obtained from Table Bay, from a position where little or no algae grew and where there was no possibility of contamination. Electrical connection was established by means of spring contact clips on small freshly filed portions of the metal that were not immersed. The experiments were divided into two classes:

A. Experiments performed in the laboratory.

B. Experiments performed actually in the sea (Table Bay).

Experimental.

Experiments "*A*".—A glass container was nearly filled with sea water, and the tip of the calomel cell (type A) was immersed to a depth of two or three inches. The flexible lead to the potentiometer was connected to the specimen of metal, and the metal was then rapidly lowered into position. Zero time was regarded as the instant at which the metal reached the requisite depth of immersion.

Readings were then taken at intervals of one minute. In this connection it must be stated that about 10–15 seconds before taking a reading

an approximate value was obtained, so that an accurate reading could be obtained exactly on the minute.

Readings were taken every minute for about the first fifteen-minute period. After this it was usually found that the change in potential per minute was of the order of one or two millivolts, and the time interval was therefore suitably increased.

Values were recorded over periods of time when the specimen of metal was kept completely at rest (see fig. 1, Experiment 26). Values were also

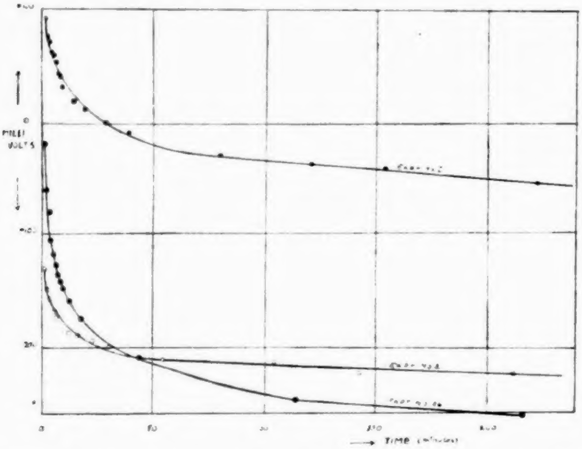


Fig. 1.—Time-potential curves of iron and steel in sea water (unstirred). In Expt. No. 26, 50 millivolts has been deducted from all the readings.

observed when the metal was rotated and the water was agitated. Experiments where the metal was rotated for certain time intervals and afterwards kept at rest, or *vice versa*, are shown in fig. 2, Experiment 19.

These curves for the potential of iron and steel are similar to the curves shown in the Seventh Report to the Corrosion Research Committee.

It was observed in all cases, where the specimen was at rest, that soon after immersion streaks of a light green precipitate appeared to be streaming away from the metal. During the next stage the solution became translucent, and finally gelatinous red ferric hydroxide appeared on the surface of the metal. The potential appears to be extremely sensitive towards the red ferric hydroxide coating. When such a specimen of metal is moved the potential value drops, and when strongly stirred so as to dislodge a large amount of the film the potential drops considerably (see fig. 2, Experiment No. 13).

During the course of most of the experiments in the laboratory it was observed that a considerable amount of ferric hydroxide had become deposited on the bottom of the container.

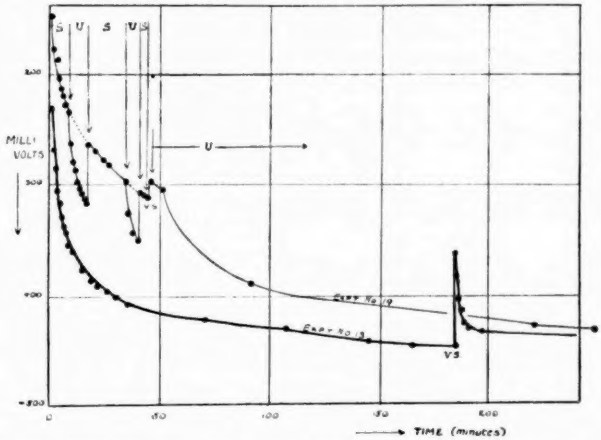


FIG. 2.—Time-potential curve of iron and steel in sea water. In Expt. No. 13, after 185 minutes, the metal rod was vigorously shaken (V.S.), and ferric hydroxide dislodged. The potential drop and the recovery curve is shown. In Expt. No. 19, "S," "U," "V.S." denote respectively periods when metal was shaken, unshaken, and vigorously shaken. In order to show both these curves in this limited space 50 millivolts has been added to all the readings here.

TABLE I.

Experiment No. 9.	Wrought iron bar (angle iron), about 6 mm. in thickness. Size 80 cm. × 8 cm.
Experiment No. 17.	Round wrought iron bar 7 mm. diameter, 30 cm. long.
Experiment No. 21.	Mild steel plate 8 mm. in thickness as used for ships' sides. Size 50 × 8 cm. (About three-quarters of the metal was immersed in sea water as the specimen was at rest during the whole period.) (This also applies to Experiments Nos. 9 and 17.)

Experiment "B".—In the case of the specimens of metal immersed in the sea the calomel electrode Type B was lowered into position. The specimen was connected to the potentiometer, and times and values recorded as before. The metal was usually suspended by rope or stout cord. Some values were obtained from specimens suspended from the deck of a wooden yacht, and another series from somewhat larger specimens suspended from

y = Millivolts. x = Time in minutes.

Experiment 9.		Experiment 17.		Experiment 21.	
y	x	y	x	y	x
..	0	..	0	..	0
+40	1	−62	1	−75	1
+12	2	−831	2	−100	2
−6	3	−101	3	−118	3
−26	4	−118	4	−133	4
−28	5	−126	5	..	5
−36	6	−133	6	−150	6
−43	7	−144	7	−159	7
−49	8	−152	8	−163	8
−52	9	−153	9	−170	9
−86	21	−159	10	−176	10
−99	33	−162	11	−180	11
		−167	12	−182	12
		−172	14	−185	13
		−203	27	−189	14
		−222	42	−191	15
		−289	125	−195	17
		−380	660	−207	21
				−240	47
				−341	987
				−350	1212
				−365	2427
				−380	3912
				−409	9732
				−414	10087
				−430	12987
				−438	15740
				−445	18350

a concrete jetty, both in Table Bay. Details of these experiments are given below. Fig. 1 (Experiments 1 and 2) shows typical curve of this series.

Curves of the "A" and "B" Series of Experiments.—In all, twenty-six experiments were conducted in the "A" series and fifteen in the "B" series. The initial values (1 minute reading) in the "A" class varied from +40 millivolts to −102 millivolts (and up to −232 millivolts when the surface was cleaned with emery and wiped with filter paper).

In the "B" class the variation was from +93 millivolts to −172 millivolts.

The observations of the forty-one experiments showed that the potential

value in every case followed a curve not very different from those shown in fig. 1. Where conditions were altered in the laboratory experiments, such as period of agitation, there was a corresponding alteration in the curve. In every case the negative potential of the metal increased with time. The maximum figure ("A" series) recorded was −475 millivolts (Experiments Nos. 30 and 31).

Resolution of Curves.—Much difficulty was experienced in attempting to obtain an expression that would be suitable for the whole curve, though several fitted isolated portions of the curve. For experimental reasons it

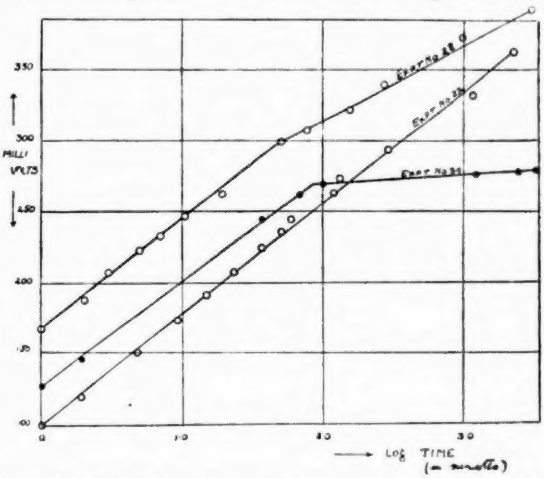


FIG. 3.—Logarithm of time-potential curve, showing break in curve in Expt. Nos. 28 and 39.

was impossible to determine the potential at either zero or infinite time. I have to thank Dr. P. R. v. d. R. Copeman of this laboratory for his kindly interest and suggestion in this matter.

It was found that the equation $y = R - K \log_{10} T$ fitted the observations (where y is the E.M.F., T is the time in minutes, R is the initial reading, and K a constant). Most of the cases studied gave negative values for y.

During the initial period of at least ten minutes the value of K remains constant, but the value of K at later stages tends to be lower, indicating a lower rate of change. Examples of these are given in fig. 3. Here the values of millivolts are plotted against the logarithm of time. Table II represents the values of K in all the experiments studied, using the above expression. In the cases where there is a change of rate, the value of K is calculated by using as origin the values for R and T, which correspond to the point at which the break in the curve occurs.

List of Experiments.

In the Laboratory.—Observations were conducted on seventeen pieces of metal—rod wrought iron and strips of steel plate.

In the Sea.—Here fourteen pieces of metal were suspended in the sea, either from an anchored yacht or from a concrete jetty.

Table II.

General equation $y = R - K \log_{10} T$.

	Initial Stage.	Secondary Stage.
Laboratory Experiments.	Average value of $K = 102$. Standard deviation $= \pm 20{\cdot}3$.	Average value of $K = 59$. Standard deviation $= \pm 10{\cdot}4$.
Sea experiments.	Average value of $K = 64{\cdot}0$. Standard deviation $= \pm 5{\cdot}0$.	Average value of $K = 34$. Standard deviation $= \pm 5{\cdot}7$ and $9{\cdot}0$.

The value of K given in the initial stage holds good until the commencement of the secondary stage. Where no data are given in the secondary stage there was no indication of any break in the straight line during the whole period of investigation. Thus, in Experiment No. 7 the value of K is 170 over a period of four minutes. After four minutes and up to sixty minutes the value of K was found to be 85·3. In Experiment No. 8 the value of K was found to be 71 for the whole of the time that observations were carried out, *i.e.* seventy-eight minutes. The average value of K in the laboratory and the sea experiments is as follows:—

	Initial Period.	Secondary Period.
Laboratory	102	59
Sea	64	34 and 9·0

The value of K is significantly different for the experiments done in the laboratory and the sea for both the initial and second periods. In the sea experiments in the secondary period it appears that there are two values for K in 34 and 9. The reasons for this are at present not apparent, but the matter is being further investigated. The contention is that the expression $y = R - K \log_{10} T$ is an empirical general expression that has been found suitable for forty-one cases of iron and steel specimens immersed in sea water.

Effect of Rotation of the Metal and Agitation of the Water.—A few experiments were conducted where the metal was rotated, and also where the sea water was stirred. The effect on the potential is clearly shown in fig. 2, Experiment No. 19. In Experiment 19 a round cylindrical bar of wrought iron, 7 mm. diameter and 30 cm. long, was taken and rotated

in sea water. About three-quarters of the bar was immersed and found to be as follows:—

R.	*K.*	Period.	Conditions.
− 99	97	1– 8	Rotation
− 187	600	8– 10	
− 232	200	10– 16	Stationary
− 216	97	17– 34	Rotation
− 250	700	34– 39	Stationary
Potential steady on − 262		40– 44	Rotation
Potential falls to − 249		44– 45	Violent rotation
− 262	300	46–800	Stationary

It was observed after periods of rotation in the initial stage that as soon as movement was arrested the surface of the metal rapidly became brown with gelatinous ferric hydroxide. Further rotation now caused the removal of the film of ferric hydroxide, and a consequent drop in potential resulted. In Experiment No. 13 the break of the curve was caused by vigorously stirring the specimen of metal and a consequent dislodgement of ferric hydroxide. A black coloration is observed on the surface of the metal where the hydroxide was dislodged. A few experiments in the laboratory on the effect of gently agitating the liquid appeared to be indifferent on the value of K. (Experiments Nos. 21, 22, and 23.)

Experiment.	Initial Stage.		Secondary Stage.		Duration.
	R.	*K.*	*R.*	*K.*	Minutes.
21	− 75	100	− 245	73·2 (T − 50)	18,300
22	− 96	81·3			4,320
23	− 26	115	− 175	70·0 (T − 20)	255

The failure in the laboratory to reproduce the constant potential of structures in the sea was a problem that afforded considerable interest. Frequently changing the sea water, bubbling oxygen, CO_2, and air, and keeping the water in a state of gentle agitation were without avail. Varying conditions of the surface, *i.e.* by using different grades of emery paper or varying the amounts of oxide were also without the desired result. As observed from the two series of experiments studied, the final values in the laboratory were considerably higher. Through the courtesy of the station manager of the Municipal Power Station, Dock Road, Cape Town,

facilities were granted to conduct experiments from a private jetty. Suitable material for the experiments was also provided.

Five iron (mild steel) bars of approximately 20 feet long were hung from the intake pipe jetty. During the course of two months the potential value decreased very gradually. These bars were first rubbed down with coarse emery cloth. Eventually a value near to the constant was reached. These bars were left for a period of some six months, and their potential

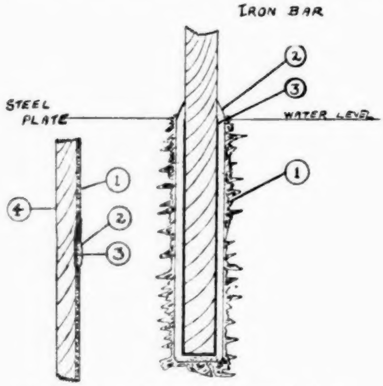


Fig. 4.—Iron bar and ship's steel plate.

In the case of the steel plate: (1) Paint film on surface exposed to the sea; (2) Fissure or break in paint film now filled with corrosion product; (3) Black film; (4) Steel plate. In the iron bar: (1) Marine growths; (2) Corrosion product; (3) Black film.

had not changed significantly. A careful examination was now made of the bars, and fig. 4 shows the details. A careful examination of ships' bottoms disclosed that in every case where the paint film had parted and where the corrosion had taken place (especially on ships' keels), the yellow-red corrosion product was observed. Underneath this (in every case) definite evidence of the black film was observed. It was noticed that there were three distinct layers completely covering the immersed iron bars:—

1. Outside layer of marine organisms (hydroids, tunicates, and polyzoa). Some of these organisms and also sea weeds tend to form an enclosing network round (2).
2. A layer of reddish-yellow corrosion product.
3. A black layer in direct contact with the metal.

The latter (3) being in direct contact with the metal was considered to be worthy of further consideration. It was observed that this black layer could be easily dislodged by gentle rubbing with the finger. On doing so a dull silvery surface of metallic iron was revealed. It was clear

that this black film was the primary corrosion product. The first attempts to preserve and analyse this product were failures. In every case the black product changed colour and was not unlike ordinary rust in appearance. When the black film dried on the metal the ordinary form of the rust was observed.

It was eventually isolated and analysed by carefully scraping away (1) and (2), and collecting (3) by means of gentle rubbing and by means of a jet of distilled water (from which all the air had been driven off by boiling). No time was lost in repeated washings with distilled water and centrifuging. It was then placed in a porcelain boat. A current of nitrogen (free from oxygen) was now passed over the boat and contents, in a suitable tube, and the whole placed in a thermostat at 105° C. In this manner about 0·2 of a gramme was obtained. The dry products gave on analysis:

Ferrous iron . . .	39·5 per cent.
Total iron . . .	56·0 ,, ,,
Sulphur . . .	5·3 ,, ,,

The collection and drying of this black film was attended by considerable difficulty. Further small quantities of the black product were collected from other immersed bars. Qualitative tests showed that the sulphur is probably present as ferrous sulphide. Distilled water suspension gave a pH of approximate 5·8. The presence of sulphur in the black film appeared to be rather significant. The origin seemed obscure. It appears, however, that the sulphur could only come from two sources:

(1) As an accumulated impurity in the iron.

(2) From the sea water:

- (*a*) By reduction of the inorganic sulphates during the process of corrosion; or
- (*b*) the possibility of the presence of other sulphur compounds in restricted areas of sea water (docks).

(1) It is possible that during the process of corrosion as the iron passes into solution impurities such as sulphur and carbon remain on the surface of the metal, and a gradual concentration of these elements results.

(2) (*a*). It is conceivable that finely divided carbon in the presence of sulphates (when the oxygen concentration drops to a very low figure) may reduce the sulphate, or that nascent hydrogen (formed during the process of corrosion) may bring about reduction under conditions where oxygen is absent.

(*b*) Sulphur in forms that do not react directly with barium chloride.

Experiments were now instituted to investigate the black film, and to determine the influence of sulphur. Attempts were first made at the artificial production of the black product. It was considered that as this

is probably an electrolytic product—a modified electrolysis of sea water using iron electrodes might serve. As this black product is formed *inside* the membrane, an electrolytic cell was employed that was fitted with inner porous cell (see fig. 5). It is contended that by making the inner electrode the anode, that iron (in a soluble form) would tend to pass through the porous cell (provided it was not precipitated). If it could remain in solution (inside the porous cell) it would only be precipitated at some

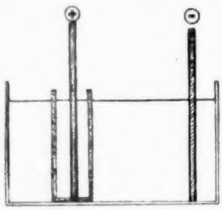


Fig. 5.—Modified electrolytic cell.

point in the walls of the porous cell where it came into contact with the outside solution. Further, iron passing through would be precipitated outside in the main solution.

In other words, the pores of the porous pot would automatically become choked with ferrous and ferric hydroxide. (Owing to the cathode being outside in the main solution the alkalinity of this solution would gradually increase.) The iron anode would then effect solution in a manner possibly not very different from the natural process. A potential difference of four volts (from a lead accumulator) was employed, and a current density of one ampere. Cylindrical rod electrodes 18 cm. long by 0·7 cm. diameter were used.

When the circuit is completed, after a short interval hydrogen streams freely from the cathode. The sea water inside the porous cell commences to assume a light brown colour and a film forms on the surface. After a few minutes magnesium hydroxide is precipitated near the cathode (owing to the alkalinity increasing). At the anode no gas formation was observed. On the sides of the porous cell, however, a few scattered small bubbles were observed.

The experiment was run for approximately three hours. Frequent tests were undertaken during the period, and it was observed that:

1. The iron anode became coated with a black film.
2. The potential of the anode decreased to $-0{\cdot}390$ volts.
3. Soluble ferrous iron compounds were formed within the porous cell.
4. Ferric and afterwards ferrous iron compounds (owing to a decrease of oxygen) were present outside the porous cell.

The fall in potential is only very gradual, and the potential of the anode tends to run consistently for several minutes on the same value. The experiment was continued until the value $-0{\cdot}377$ was reached (with the apparatus used this took approximately three hours). Several such experiments were conducted, and the summary is given below. In taking potential measurements of the anode it was observed that no significant differences in the readings were obtained by placing the calomel cell either *inside* the porous cell or outside in the main solution.

Inside the Porous Cell.

1. The anode acquires a dark colour due to a black film. This appears to be similar in many respects to the natural product. It also readily undergoes oxidation, changing into a red colour.
2. Soluble iron compounds are present.
3. Only a trace of ferric iron was detected.
4. No free chlorine or H_2O_2 was detected.
5. The concentration of sulphate increases.
6. Chloride concentration had apparently suffered no change.

Solution outside the Porous Cell.

1. The amount of alkali increases.
2. Hypochlorites are present.
3. Ferrous and ferric iron compounds are present.

Although analytical determinations were conducted when the potential attained $-0{\cdot}377$ volts in five experiments, variations were found. The figures given below are the mean of five. The current was sometimes varied, otherwise the same conditions were maintained. The amount of iron in solution inside the porous cell was found to be 22·4 grm. Fe per 1000 c.c. Likewise the amount of sulphate 1·24 grm. of S per 1000 c.c. The black film was dislodged and treated as before. This gave on analysis:

Ferrous Iron	35·2 per cent.
Total iron	67·0 ,, ,,
Sulphur	2·3 ,, ,,

The Influence and Effect of Sulphur in Corrosion.—Certain marine growths give off hydrogen sulphide, and to this cause has been ascribed marked pitting of iron piles in Hong Kong harbour (Ellis *). Hydrogen sulphide when present in water makes the water acid and causes rapid corrosion (Speller †). Sulphur and FeS are cathodic to iron. Thus they probably localise the corrosion by increasing the cathodic area available for depolarisation of nascent hydrogen. Hydrogen sulphide in illuminating

* S. H. Ellis, Proc. Inst. Civil Eng., 199, 137, 1914.

† Speller, Textbook on Corrosion.

gas in conjunction with the oxygen and water vapour present is an important factor in accelerating the interior corrosion of gas mains. Evans * likewise mentions the corrosive effect of water containing H_2S on marine condensers.

The corrosion of iron in tap and natural waters was accelerated 95 per cent. and 68 per cent. respectively at 17° C. owing to direct contact with FeS. In a 1 per cent. NaCl solution direct contact of FeS with Fe accelerated the corrosion of the Fe 2·3 times. In direct contact by means of iron wire the corrosion rate was increased 4·7 times (Stumper †).

Industrial benzene contains CS_2 and C_6H_5S. Both these substances are considered important impurities from a corrosion point of view (Sei Fugio ‡). Crude oils with a high sulphur content also cause considerable corrosion (Reid §).

A case of corrosion due to hydrogen sulphide in natural gas engines is given by Maleev.‖ Gas containing 5 per cent. H_2S was quite corrosive until freed of water. Then it could be used without difficulty.

The presence of sulphur in the black film (5 per cent.) in the natural corrosion product and in the artificial (2 per cent.), and the fact that an increase of sulphates was observed in the latter experiments in the inner cell led to further experiments in this direction.

The Effect of Sulphur on the Potential of Iron.—Sea water was used to which 1 c.c. of $(NH_4)_2S$ (bench reagent approximate strength 5N) was added to 500 c.c. of sea water. Short iron bars 20 c.c. long were dipped into this solution. The surface of the iron was cleaned with two grades

Time (minutes).	Potential (volts).
0	..
$1\frac{1}{2}$	−0·298
3	−0·347
5	−0·377
9	−0·400
19	−0·450
34	−0·477
39	−0·492

of emery cloth, and finally wiped with filter paper. After a few minutes black spots (nuclei) were observed at the anodic areas. After about three

* Evans, Textbook on Corrosion.

† R. Stumper, Compt. Rend., 176, 1316–17, 1923.

‡ Sei Fugio, Bull. Naval Fuel Store House Lab. 2, p. 65, 1928.

§ Reid, Refiner Natural Gas Manufacture, vol. vii, No. 8, pp. 59–62, 1928.

‖ Maleev, Power, vol. lxxiv, pp. 127–28, 1931.

hours the whole of the metal surface exposed was covered with a black film. Specimens of iron and steel immersed in such a solution showed a remarkably rapid rise in potential.

When sulphur in a fine state of division is placed in a beaker containing sea water in which polished bars of iron are immersed, the surface of the iron also acquires a black film of sulphide. On exposing such bars to the atmosphere they become covered with red rust. The iron sulphide on oxidation is converted into Fe_2O_3 and sulphur.

Potentials of Iron Sulphide.—Solution potential experiments were conducted, using ferrous sulphide. Rods about 10 cm. long by 1·8 cm. diameter

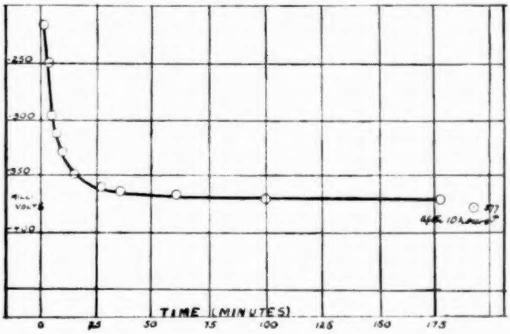


FIG. 6.—Timie-potential curve of iron sulphide in sea water.

of Merck's "Ferrum Sulfuratum fusum in bacillus—pro analysi" were taken and immersed in sea water at the laboratory. About one litre of freshly collected sea water was taken, and about three-quarters of the rod of iron sulphide was immersed.

Time-potential curves were obtained. Six such experiments were undertaken. Fig. 6 shows a typical curve of this series. It was observed in two of the above experiments that after twelve hours $-0·377$ volts was obtained. In the remaining cases higher values were obtained for this period ($-0·390$). On taking the specimens out of the water and reimmersing them in freshly collected sea water $-0·380$ volts were obtained. [In the case of the iron and steel bars considerably higher values (about $-0·400$ volts) were observed.] It will also be noticed that this curve is not of the asymptotic type, and tends to flatten out at an early stage.

Experiments in which bars of wrought iron were immersed in 3 per cent. NaCl (chemically pure sodium chloride) solution saturated with CO_2 at 19° C. gave similar curves and final potentials of the order of $-0·380$ volts.

The Corrosion of Zinc (Protector) Plates.—In connection with the submerged corrosion of iron in sea water mention must be made of the use of zinc as a protective means. Many vessels, especially naval vessels belonging to H.M. Government, are fitted with phosphor bronze propellors. Being in contact with the iron hull under water they tend to set up an intensive corrosion. The effect of dissimilar metals in contact (under water) is very clearly indicated in the case of the *Sea Call* (mentioned in the textbooks of Evans and Speller).

To afford protection to the iron hull when phosphor bronze or similar alloys are used for propellors, zinc protector plates are fitted. The disposition of these zinc plates is a matter of marine engineering. They are usually placed in the close proximity of the propellor. Zinc protectors are also placed where the hull is pierced (to allow brass pipes from pumps, etc., to discharge or take in water).

The general practice is to clean the portion of the hull where the zinc slabs are to be fitted with emery cloth, etc., and to bolt the zinc plate securely down. The main factor is to establish a firm electrical contact. (These plates are not painted.) In the region of the propellor zinc plates are also fitted to the "A" bracket (the bracket holding the shaft in position), the part of the rudder nearest the propellors, and on to the outside covering of the shaft. The specification for the zinc used here was:

1. In the case of naval vessels: "Not to contain more than 1·1 per cent. lead. A sample of the proposed material to be forwarded to the Admiralty for analysis."
2. In the case of the tug *Ludwig Wiener*: "Ordinary pure commercial zinc." A sample of zinc (metal) from the uncorroded parts of the zinc plate was found to contain a trace (less than 0·01 per cent.) of sulphur.

Analysis of Corroded Zinc Protection Plates.—When vessels are periodically hauled out of the water or dry-docked the zinc plates are examined and renewed (if necessary). Samples of zinc (corroded under such conditions) from local vessels were examined. They were all found to be apparently free from marine growths (possibly bacteria—but no evidence of the usual marine organisms).

Bengough and May * state that the chief corrosion products of zinc in sea water are the carbonate, hydroxide, and oxychloride. The last-named is formed by the interaction of the zinc chloride formed at anodic areas with the sodium hydroxide formed at cathodic areas or with zinc hydroxide. The oxychloride occurs in the scale as hexagonal or micaceous plates or as granular material. This together with the hydroxide forms a protective scale on the zinc. Recently, when the Administration's tug

* Bengough and May, Journ. Inst. Metals, vol. xxxii, p. 81.

Ludwig Wiener was dry-docked, a sample of corroded zinc was obtained. The instant that the water was pumped out of the dock a small sample was scraped off (with a clean wooden scraper). This was immediately taken to the laboratory, weighed, and placed in a thermostat at 105° C.

This was found to contain 21·4 per cent. water. The moisture-free material was found to contain a considerable amount of sulphate. It was observed that the zinc plates had suffered considerable corrosion. The surface of the metal was very badly pitted. The complete plate was removed (as it required to be renewed), and further samples of the corrosion product were taken and analysed for sulphate.

These results gave the following figures. Samples of air-dried corroded zinc from similar sources were obtained. All the specimens were ground in a mortar and dried at 105° C. A weighed quantity of about 0·5 gramme was taken and oxidised with bromine and hydrochloric acid. The sulphate was estimated by the usual standard method, and the results were all calculated as sulphur. When a large specimen was available several samples were analysed.

1. Administration tug *Ludwig Wiener*—this particular piece of zinc had been under water for 10 months, and was bolted to a rudder plate.

2. Sample from "A" bracket, H.M.S. *Carlisle*.

3. Sample from H.M.S. *Verbena*, main inlet valve (outboard), renewed six months previously. During the period which corrosion took place the ship was lying alongside a wall for four months in H.M. Dockyard, Simonstown.

Sulphate in air-dried samples of Corroded Product (rendered moisture-free by heating to 105° C.).

	1.			2.		3.
Sulphur (per cent.) .	5·27	4·12	4·45	5·73	5·77	4·50

In connection with sample 1, scrapings of the corrosion product were obtained:

(*a*) From the interior or sides of "pits" or holes in the sheet.

(*b*) From the surface of the metal where no "pit" had formed.

Both samples were rendered moisture-free by heating the powdered material to 105° C.

	Sulphur.	Fe_2O_3.
(*a*)	4·05 per cent.	3·90 per cent.
(*b*)	4·37 ,, ,,	2·65 ,, ,,

All the specimens of corroded zinc examined, except one, had been air-dried before arriving at the laboratory. The specimen did not yield H_2S on treatment with acid. It is not possible to state if zinc sulphide was originally present and had oxidised. As the atomic weights of iron and zinc are relatively close, and one atom of metal combines with one atom of sulphur, approximately the same quantity of sulphur would be required in the corrosion product of zinc and of iron.

The amount of sulphur (in the form of sulphates) present in sea water is approximately 0·1 per cent. In dock areas considerable amounts of coal (in the form of fine dust and lumps) due to ships coaling, drop into the water. Here also is a certain amount of restriction of water movement, and an accumulation of decaying organic matter results. These factors and the fact that a heterogenous collection of material finds its way into dock areas, led to investigating of dock sea water:

A. Sulphates in increased concentration.

B. Alkali sulphides.

C. Organic sulphur—etherial sulphates (indoxyl or skatoxyl sulphate), thio acid derivates.

Analysis of sea water from dock areas disclosed that negative results were obtained for A, B, and C above.

Summary.

The general theory of the submerged corrosion of ships is discussed. Observations on the film potential of twenty-one iron and steel structures gave a constant value of $-0{\cdot}377$ volts (standard error $\pm{\cdot}0028$).

The presence of a primary and secondary film on sea-water corroded iron and the significance of sulphur in the primary film are discussed, together with the occurrence of sulphur in corroded zinc plates on ships' bottoms, and the possibility that the constant film potential is an iron sulphide—CO_2 reaction. The time-potential of ships after cleaning and painting is given, and the time-potential curve of iron and steel in sea water has been determined.

Acknowledgments.

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THE ASCIDIANS OF THE CAPE PROVINCE OF SOUTH AFRICA.

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(Communicated by T. A. STEPHENSON.)

(With Plate VII.)

The present account is based upon the rich material collected by Professor T. A. Stephenson on the southern coast of the Cape Province, especially at Still Bay. This material contained some very interesting species, and enables me to clear up certain doubtful faunistic points. While studying the material I was stimulated to pursue its geographical relations, and for this purpose I must take into consideration the whole Ascidian fauna of the Cape Province. Before dealing with the geographical relations, I will present a list of the known Ascidians of the Province, as complete as I am able to make it. This list contains three columns.

The greater number of the species mentioned in the *first column* are littoral Ascidians from the southern coast of the Cape Province, from the Cape of Good Hope in the west to Cape Padrone in the east. In order to make a complete Ascidian fauna of the Province, I have added in square brackets species of Ascidians known from other parts of the coast, including the non-littoral species which occur farther away from the shore, beyond the 200-m. line. I have not excluded any doubtful species from this list, but I have added critical notes on their systematic value wherever possible.

In the *second column* I have given the localities within the region of the Cape Province; those not belonging to the littoral part of the southern coast as limited above, in square brackets. Some locality-notes leave it uncertain whether they should be put in parentheses or not. For instance, the specimens collected by Schmarda bear only the note: "Cap." From the report of his voyage (1861, pp. 68, 69) we may conclude that most of these specimens were collected in the vicinity of Cape Town (rocks behind the Amsterdam Battery noted as especially rich from a faunistic point of view). But some species may come from Simon's Bay. I have put all these somewhat doubtful localities in parentheses. The abbreviations used in the second column are as follows:—

Port Nolloth—No; Table Bay—Ta; vicinity of Cape Town (including, for instance, Sea Point)—Ca; doubtful locality (mostly vicinity of Cape Town—"Cap"; Saldanha Bay—Sa; Cape of Good Hope—Cgh; False Bay—Fa; Walker Bay—Wa; Agulhas Bank—Agu; Still Bay—St; Knysna—Kn; Plettenburg Bay—Pl; Francis Bay—Fr; Algoa Bay—Alg.

In the *third column* I have noted the further distribution of the species, and in curved brackets the distribution of allied forms. The succession of the localities is arranged in the direction from west to east. The localities westward from the Cape, as well as those reached by a northward line through the Atlantic, are distinguished from the eastern ones by a square bracket following the record and none preceding it.

DISTRIBUTION OF THE ASCIDIANS OF THE CAPE PROVINCE.

Species.	South African Records.	Further Distribution.
Family SYNOICIDAE.		
**Amaroucium erythraeum*, Mich.	[Ta], Fa, St, Fr	Red Sea, New Zealand.
Amaroucium circulatum, Hartmr. (sp. inc., identical with the preceding one?).	Fr	
Amaroucium exiguum (Herdm.).	Cgh 176 [-318] m.	
[*Amaroucium subviride*, Herdm.] (sp. inc., identical with the preceding one?).	[Cgh, 270 m.]	
Amaroucium galeritum, Hartmr.	Fr.	
[*Amaroucium astraeoides*, Sluit.] (sp. inquir.).	[Ca]	
[*Amaroucium simplex*, Sluit.] (sp. inc., identical with the preceding one or with *A. astraeoides*, Sluit.?).	[Ca]	
Amaroucium flaveolineatum, Sluit.	Pl	
Amaroucium obesum (Sluit.).	Fr [or Pl?]	
Amaroucium claviforme (Hartmr.) (sp. inquir.).	Alg	
[*Amaroucium colelloides*, Herdm.] (sp. inquir.).	[Cgh, 270 m.]	
Aplidium agulhaense, Hartmr.	Agu	
Aplidium schultzei, Hartmr.	Fa	
Atopogaster elongata, Herdm., var. *pallida*, Herdm. (gen. spur., sp. inquir., perhaps identical with the preceding one).	Fa	
["*Polyclinum complanatum*, Herdm.?"] (quite uncertain species; even its author is doubtful whether or no it is identical with the Australian *P. complanatum*. The latter is doubtful itself, and certainly no *Polyclinum*).	[Sa?]	
[*Polyclinum neptunium*, Hartmr.].	[off Ca, 106 m. Cgh, 318 m.]	South-western Australia.

Species.	South African Records.	Further Distribution.
Family CLAVELINIDAE.		
Clavelina enormis (Herdm.).	Fa	Moçambique, Mauritius, Zanzibar, Tschagos Archipelago, South-western Australia. Red Sea?.
[*Polycitor nitidus* (Sluit.)].	["Cap"]	Natal.
Sigillina (*Sigillina*) *p. sammophora* (Hartmr.).	Agu	
**Sigillina* (*Hyperiodistoma*) *illota* (Sluit.).	[Ta] Fa	
[*Sigillina* (*Hyperiodistoma*) *möbiusi* (Hartmr.)].	["Cap"]	Natal, Moçambique, Madagascar, Mauritius, German East Africa.
**Sigillina* (*Eudistoma*) *rhodopyge* (Sluit.), var. *kauderni* (Mich.).	Fa, St	Madagascar, all. forms: Moçambique and Madagascar (f. *typica*).
**Sigillina* (*Eudistoma*) *coerulea* (Sluit.)?.	St ?	Natal.
Sigillina (*Eudistoma*) *renieri* (Hartmr.).	Ta, Fr	
Distaplia cerebriformis (Q. and G.).	[Ca] Wa	North-west, South-west, South, and East Australia.
**Distaplia capensis*, n. sp.	Fa, St	(All. sp. of *D. fasmeriana*, Mich., from New Zealand.)
Distaplia skoogi, Mich.	Wa	
Distaplia domuncula, Hartmr.	Fa	
Cystodytes roseolus, Hartmr., f. *typica*.	Alg	Seychelle Islands, all. forms: Guinea Islands (var. *greeffi*, Mich.)].
Family DIDEMNIDAE.		
**Didemnum stilensis*, n. sp.	St	(All. t. *D. helgolandicum*, Mich.?, German Sea, Northern Atlantic)].
**Didemnum seychellense*, Mich.	Fa	Seychelle Islands.
**Didemnum velans*, Mich.	St	Zanzibar.
[*Didemnum savignyi*, Herdm.].	[Cgh, 270 m.]	
[*Didemnum edwardsi*, Herdm.].	[Cgh, 270 m.]	
[*Didemnum speciosum*, Herdm., var. *asperum*, Herdm.] (spec. inquir.).	[Cgh, 270 m.]	
Didemnum? *luteolum*, van Name. (spec. inc.).	Fa	
[*Didemnum spongioides* (Hartmr.)].	[Cgh, 380 m.]	
[*Didemnum chuni* (Hartmr.)].	[Cgh, 380 m.]	
**Leptoclinides capensis*, n. sp.	St	(All. sp. of *L. faeröerensis*, Bjerk., Northern Atlantic)].
[*Diplosomoides capensis*, Hartmr.].	[Cgh, 380 m.]	
Trididemnum cerebriforme, Hartmr.	Fa	
Family RHODOSOMATIDAE.		
**Corella eumyota*, Traust.	[Ta], Fa	South America from Tierra del Fuego to Valparaiso and Southern Brazil; Antarctic Seas; South-west Africa]; St. Paul in the Southern Indian Ocean; Tasmania; Auckland Islands; New Zealand; Chatham Islands.

Species.	South African Records.	Further Distribution.
Family Ascidiidae.		
**Ascidia sydneiensis* (Stimps.).	Fa, St, Kn	West Indies; Cape Verde Islands]; Zanzibar; Seychelle Islands; Northern, Western, and Eastern Australia; Malay Archipelago; Japan; Otahiti in the South Pacific.
**Ascidia incrassata*, Heller.	[Ta], Fa, St	Moçambique.
Ascidia compta, Sluit.	Kn	
Ascidia multitentaculata, Hartmr.	Fr	
[*Ascidia krechi*, Mich.].	[Cgh, 318 m.]	
[?*Phallusia nigra*, Sav.].	[probably Cgh, 270 m.]	Bermuda Islands; West Indies; Brazil]; Gulf of Aden; Red Sea.
Family Styelidae.		
**Botrylloides leachi* (Sav.).	[Ta], Fa	Northern Atlantic; Europe from Western Norway as far as the Western Mediterranean]; Western Australia; Auckland Islands; New Zealand.
?[*Botrylloides nigrum*, Herdm.]. (It is doubtful whether the specimen marked "Cap" really belongs to this species or to the foregoing.).	["Cap"]	Bermuda Islands; West Indies]; Moçambique; German East Africa; Red Sea; North-western, Western, and South-eastern Australia; Bismarck Archipelago ("Neu-Pommern"); ?Malay Archipelago.
*[*Botryllus magnicoccus* (Hartmr.)].	[Ta], ["Cap"]	South-west Africa].
[*Chorizocarpa monocarpa* (Sluit.)].	[Ta, Ca]	?Northern Australia (all. sp. Eastern Australia).
**Symplegma elegans* (Q. and G.).	[Ca], St	Gulf of Mexico]; Mauritius; German East Africa; Red Sea; Western Australia; Philippines. (Allied species, *S. viride*, Herdm., Bermuda Islands.)
Polyzoa falclandica, Mich.	Fr	Falkland Islands].
Alloeocarpa capensis, Hartmr.	Fr	(All. sp. Tierra del Fuego. South Patagonia; Falkland Islands; South Georgia)].
Gynandrocarpa placenta (Herdm.) (incl. *G. domuncula*, Mich., which I now regard only as modified to form a habitation for a crab (*Dromia*), or an allied genus).	[Ca], Fa, Agu, Alg	German East Africa.
Oligocarpa skoogi, Mich.	Ta	(All. sp. *O. megalorchis*, Hartmr., Kerguelen).
Polycarpa tritonis (Mich.).	Pl., 100 m.	
Polycarpa anguinea (Sluit.).	Kn	
[*Cnemidocarpa asymmetra*, Hartmr.].	[Ca]	South-west Africa].
Styela angularis (Stimps.).	Fa	South-west Africa].
Styela pupa, Sluit.	Fa	
**Styela stephensoni*, n. sp.	Fa, St	(All. sp. *S. marquesana*, Mich., Moçambique).

Species.	South African Records.	Further Distribution.
Family PYURIDAE.		
[*Microcosmus oligophyllum*, Heller, f. *typica*].	["Cap"]	
**Microcosmus oligophyllum*, Heller, var. *wahlbergi*, Mich.	St	Natal.
Microcosmus albidus, Mich.	Fr, 100 m.	
Pyura stolonifera, Heller.	[No, Ca], Fa; Pl, 100 m.; Alg	South-west Africa]; Natal; Western Australia (subsp. *waia*, Mich.); Eastern Australia; South Sea (Tahiti).
Pyura capensis, Hartmr.	Fr	(All. sp. *P. morus* (Forbes), North-western Europe)].
Pyura momus (Sav.), f. *pallida* (Heller).	Fa	Bermuda Islands; West Indies]; Mauritius; German East Africa; Gulf of Aden; Seychelle Islands; Ceylon; Western Australia; Malay Archipelago; South Sea.
Family MOLGULIDAE.		
Ctenicella conchata (Sluit.).	Kn	(All. sp. *C. natalensis*, Mich., Natal).

GEOGRAPHICAL RELATIONS OF THE ASCIDIAN FAUNA OF THE CAPE PROVINCE.

There are many species in the above list which do not occur outside the region of the Cape Province, and which do not show any special affinity to allied Ascidians from elsewhere. These species, as well as all doubtful and valueless ones (spec. inqu., spec. spur.), are omitted from the following discussion.

By far the greatest number of the remaining south coast species show a geographical relation to the warmer regions eastwards of Africa, to the Indian Ocean (including the Red Sea), to Australia, the Malay Archipelago, and even to Japan and the South Sea. These species are: *Clavelina enormis* (Herdm.), as far as South-western Australia; *Sigillina* (*Eudistoma*) *rhodopyge* (Sluit.), var. *kauderni*, Mich., as far as Moçambique and Madagascar; *S.* (*Eu.*) *coerulea*, Sluit.?, up to Natal; *Distaplia cerebriformis* (Q. and G.), as far as Australia; *Didemnum seychellense*, Mich., to the Seychelle Islands; *D. velans*, Mich., to Zanzibar; *Botrylloides leachi* (Sav.), as far as Western Australia and New Zealand; *Microcosmus oligophyllum*, Heller, var. *wahlbergi*, Mich., up to Natal; and *Ctenicella conchata* (Sluit.), to Natal. To these species, clearly belonging to the warmer eastward region, may be added certain others, which besides this eastward relation extend a little way northwards on the western coast of Africa, but not beyond the west

coast of the Cape Province. These are ***Amaroucium erythraeum***, Mich., eastward as far as the Red Sea and New Zealand; ***Polyclinum neptunium***, Hartmr., eastward to Western Australia; probably ***Polycidor nitidus*** (Sluit.), eastward to Natal; probably ***Sigillina*** (***Hyperiodistoma***) ***möbiusi*** (Hartmr.), eastward to German East Africa; ***Ascidia incrassata***, Heller, eastwards as far as Moçambique; *Chorizocormus monocarpa* (Sluit.)?, ? eastwards as far as Northern Australia; and *Gynandrocarpa placenta* (Herdm.), eastward to German East Africa. Somewhat farther north, on the west coast of South Africa, as far as South-west Africa, extends ***Pyura stolonifera*** (Heller), whose eastward range reaches Australia and the South Sea. Perhaps still farther northwards (but this is not certain), as far as Angola, extends *Styela stephensoni* n. sp., which on the east coast reaches Moçambique.

From this compilation we may recognise that *the greater part of the Ascidian species has been transported to the south coast of Africa from the Indian Ocean by the warm Moçambique current coming down through the Moçambique channel.* The westward advance of these warm-water Ascidians is generally cut off sharply by the cold Benguela current, a branch of the Westwind Drift, before passing the meridian of Cape of Good Hope. Only a few species succeed in extending from beyond the Cape of Good Hope *a short distance northward along the western coast of South Africa.* Two extend even as far as South-west Africa (a doubtful species perhaps as far as Angola). The west coast of Africa presenting very unfavourable conditions for the existence of warm-water Ascidians, this last-mentioned branch of the fauna soon reaches its limit. (It is doubtful whether the species *Ctenicella asymmetra* (Hartmr.), *Styela angularis* (Stimps.), and *Chorizocarpa monocarpa* (Sluit.) belong to the present group. Up to the present we do not know, at least not certainly, of their occurrence farther east.)

There is a further group of eastern warm-water Ascidians, which succeed in passing the meridian of the Cape of Good Hope westward, and which finally reach the warmer parts of the Atlantic. These species are ***Cystodytes roseolus*** Hartmr., eastward to the Seychelles, westward to the islands of the Gulf of Guinea; *Ascidia sydneiensis* (Stimps.), eastward to Japan and the South Sea, westward to the Cape Verde Islands and the West Indies; ***Phallusia nigra***, Sav. (doubtful whether from the Cape), eastward to the Red Sea, westward to the West Indies and the Bermudas; ***Botrylloides nigrum***, Herdm., eastward to the region of New Guinea, westward to the Bermudas; *Symplegma elegans* (Q. and G.), eastward to the Philippines, westward to the Bermudas; and *Pyura momus* (Sav.), f. ***pallida***, Heller, eastward to the South Sea, westward to the Bermudas. Since the southern corner of South America reaches far into the cold notal region, there remain

only two ways which may lead warm-water Ascidians from the Indian Ocean to the warmer parts of the Atlantic; the first through the Red Sea and the Mediterranean, the second round South Africa. It must be noted firstly that none of the Indic-Atlantic species occur in the Mediterranean. Previously, in considering the relation of the Ascidian fauna of the Red Sea to that of the West Indies (1918A, p. 4) I have shown that its route must have been *via* the Cape, in spite of the fact that some of the species in question have not yet been found on the south coast of Africa (for instance, *Polyclinum constellatum*, Sav.). Another fact must now be considered. None of the Indic-Atlantic species occur on the west coast of Africa and of Europe. The coast line of West Africa, with its very scanty Ascidian fauna, is no route for warm-water Ascidians. Only two of the Ascidians in question approach fairly near to this coast, but without reaching it; they remain in the warmer region of the islands at a certain distance from the shore—*Cystodytes roseolus*, Hartmr., from São Thomé in the Gulf of Guinea; and *Ascidia sydneiensis* (Stimps.), from the Cape Verde Islands. All the other Indic-Atlantic Ascidians occur in the western part of the warmer Atlantic, mostly in the West Indies and at the Bermudas, but they are also found on the Brazilian coast, or in the middle of the southern Atlantic—at St. Helena. In notifying the occurrence of *Polyclinum constellatum*, Sav., at St. Helena (1923, p. 2), I indicated this island as an intermediate station on the route of the warm-water Ascidians from the Indic to the western regions of the middle Atlantic. Indeed, data about such intermediate stations between Cape Province and the West Indies are very scanty (apart from the Ascidian from St. Helena, we can only note the Brazilian coast as an intermediate station of *Phallusia nigra*, Sav.). This scantiness is, however, not a matter of fact, but only a consequence of lack of examination. The east coast of South America is almost the least known part of the earth in regard to the fauna of Ascidians. We may then make the following summary: Some of the South African Ascidians mark the route of eastern species from the warmer Pacific and (or) Indic to the western regions of the warmer Atlantic, crossing the Atlantic in its southern part, and giving off only scanty branches to the tropical eastern Atlantic, and not reaching the west coast of Africa. The Mediterranean is no path of distribution for Indic-Atlantic Ascidians.

Of quite another character is the distribution of several other Ascidians from the Cape Province, which we must regard as cold-water Ascidians. These show a distribution or an affinity-relation more or less definitely in the west-to-east direction, sometimes from the western region of the Straits of Magellan as far as the Cape Province (*Polyzoa falclandica*, Mich., and *Allococarpa capensis*, Hartmr.), and sometimes from the Cape Province to Kerguelen (*Oligocarpa skoogi*, Mich.) or to New Zealand (*Distaplia capensis*,

Mich.). These species are members of the subantarctic Ascidian fauna carried to or from South Africa by the subantarctic Westwind Drift. To these subantarctic species perhaps must be added a species with a very remarkable distribution, namely, *Corella eumyota*, Traust. The principal distribution of this form makes it appear as an antarctic-subantarctic species. It is circumpolar in Antarctic (collected at three stations very distant from one another) as well as in the subantarctic region (Tierra del Fuego, Cape Province, St. Paul in the southern Indian Ocean, Tasmania, Auckland Islands, New Zealand, and Chatham Islands). But this curious species so abundant in the colder and coldest regions, extends in different directions far to the north, into warm water and even into tropical regions as far as Valparaiso in Chile, Babia in Brazil, and Luderitz Bay in South-west Africa. The more northern stations on the west coasts of South America and South Africa may be regarded as outposts carried forward by the northward branches of the subantarctic Westwind Drift, the cold Peru current, and the cold Benguela current. But the station "Babia," directly in the hottest tropical region, appears to me inexplicable, since the cold Falkland current along the east coast of Patagonia and Argentina vanishes long before reaching the tropics. It is possible that the locality-note "Babia" for *C. eumyota* depends upon a mistake? Perhaps there may have occurred a permutation of locality-labels, or a mistake in the determination of the species? Confirmation of this record must be given before I can regard it as correct.

Finally we have to note still another singular mode of distribution, namely, a *bipolarity of distribution*. Some species of the south coast of Africa seem to be nearly allied, not to species of neighbouring regions, but to species of a region far distant from the Cape. These species are *Leptoclinides capensis*, n. sp., to all appearance allied to *L. faeröerensis*, Bjerk.; *Didemnum stilensis*, n. sp., probably allied to *D. helgolandicum*, Mich.; and *Pyura capensis*, Hartmr., according to its author nearly allied to *T. morus* (Forbes). All three, then, are presumably allied to species found in the North Atlantic or on the western coast of Europe. But whilst these South African species are only *allied* to northern species, there is a fourth which itself inhabits northern Atlantic and European localities, but is wanting in the intermediate warmer regions; this species is *Botrylloides leachi* (Sav.). In this case the wide interruption in the range of the species may perhaps be explained by the fact that it is represented in the intermediate region by a very nearly allied species, *B. nigrum*, Herdm., which may be only a warm-water form of *B. leachi*. *B. nigrum* may have become altered, under the influence of lower temperatures, to *B. leachi* in both a northerly and a southerly direction from the tropics.

Summary.

The Ascidian fauna of the southern coast of Africa is composed of two different elements. The greatest part of it has migrated from the warmer eastern seas of the Pacific and the Indian Ocean. Most of these eastern species find a limit at the meridian of the Cape of Good Hope, being cut off here by the cold Benguela current. A smaller number of species succeed in passing this meridian westwards. Here the line of distribution bifurcates. A few species go directly northwards along the west coast of South Africa, soon dying out on this unfavourable coast, a few only reaching South-west Africa and one, perhaps, even Angola. The other line of distribution crosses the Atlantic and reaches (*via*, for instance, St. Helena) the east coast of South America, thence running northwards to the West Indies or even to the Bermuda Islands. Small branches diverge from this line towards the Cape Verde Islands and the Gulf of Guinea. The Mediterranean does not by any means form a path connecting the Ascidian fauna of the Indian Ocean (including the Red Sea) with that of the western tropical Atlantic. A minor part of the Ascidian fauna of the South African coast, the cold-water element, depends upon the subantarctic Westwind Drift. A small number of the South African Ascidians seem to have a bipolar distribution.

DESCRIPTIVE PART.

Amaroucium erythraeum, Mich.

(Plate VII, fig. 1.)

1906. *A. ritteri*, Sluiter, 1906, p. 15 (partim, specimens from d'Urville Island, perhaps also those from French Passage, but not the types from Torres Strait, Sluiter 1895, p. 170).
1906. *A. obesum*, Sluiter, 1906, p. 17 (partim, the smaller colony, but not the larger type-colony represented in fig. 9 on Pl. I). (Not identical with *A.* (*Psammaplidium*) *obesum*, Sluiter 1898, p. 28, from the Cape Province.)
1920. *A. erythraeum*, Michaelsen, 1920A, p. 17, Pl. I, fig. 10.
1921. *A. erythraeum*, var.? Michaelsen, 1921, p. 19.
1924. *A. phortax*, Michaelsen + var. *ptychodes*, Michaelsen, 1924, p. 389.

Localities.—False Bay, Seaforth (11/6/1932), and St. James (24/3/1932). "Occurs sometimes in exposed places, sometimes under overhanging rocks." Still Bay, under stones in pools (19/1/1932).

Remarks.—This species is characterised by the large number of the folds of the stomach. This number varies between 24 and 29 in the typical form of *A. erythraeum*, between 29 and 32 in the var. *ptychodes*. As most of the synonyms above cited are discussed in connection with the description of *A. phortax* (Michaelsen, 1924, pp. 397–399), it is necessary here only to demonstrate the identity of this species with *A. erythraeum*. In creating

the species *A. phortax* as distinct from *A. erythraeum*, I was of the erroneous opinion that the presence or absence of the superficial incrustation should be regarded as a sufficient character for separating the species. The new specimens from the Cape Province show that the superficial incrustation is very variable—figs. 1A and 1B show two very different states of it—probably depending upon the nature of the locality. For this species alone (and not for any other species of the large collection) Professor T. A. Stephenson mentions the variability of the locality. Surely any current whirling the sand about will further the incrustation of an animal living near sandy grounds, while specimens attached to the undersides of overhanging rocks far from sandy ground are deprived of incrusting materials. In a colony from St. James we see a thick incrustation just like that of the type-specimen from the Red Sea; a large specimen from Seaforth has a very scanty incrustation; and lastly, a smaller specimen from Seaforth has no incrustation at all, as in the type-specimen of *A. phortax*. The arrangement of the zooids in groups is somewhat different in different colonies (see figs. 1A and 1B). The groups are very regular in the colony from St. James (fig. 1A), where they are mostly circular or oval, irregular groups occurring only at the margin of the colony. The incrustation here is restricted to the parts between the groups of zooids. The incrusted parts of the colonial surface being bright white, these groups are striking because of their dark colour. The number of zooids in such a group varies from 5 to 12. These darker parts of the colonial surface have the form of areas with a crenate margin. Each of the semi-circular scallops round these areas corresponding to a zooid of the group, contains in its centre a six-rayed branchial orifice, whilst in the centre of the whole group there is a large irregular cloacal aperture (*ca.* ½ mm. wide), somewhat darker than the dark surrounding field. Such regular groups of zooids occur also in the other colonies, but intermingled with irregular groups, and sometimes very scanty and indistinct. These other colonies have cloacal apertures of the same form (as has also the type-specimen from the Red Sea, which I am not able to re-examine). I have seen them distinctly in the specimens from Seaforth (fig. 1B) and from Table Bay (though not mentioned in the original description of the latter).

The colour of the living animals, according to the collector, is as follows: "Zooids pinkish brown, with straw-coloured siphons, intermediate tissue grey," or "transparent, with bright red zooids," or "transparent, with red zooids." Even in the preserved colonies a bright red-brown or bright orange colour is visible, and is strictly limited to the thorax of the zooids.

Cloacal Chambers.—The small cloacal apertures on the surface of the colony lead into small and rather flat cloacal cavities close beneath the thin superficial membrane, perforated in the centre like a diaphragm. From these cloacal cavities radiate very narrow cloacal canals, close beneath the surface of the colony, presumably running to other groups of zooids or to single, isolated zooids.

The zooids are remarkable for the variation in their length (as already stated in the original description). In the colony from St. James their length varies from 3 to 15 mm., and this depends principally upon the different lengths of the post-abdomen. It is noteworthy that in large parts

of a colony, especially in the marginal parts, there occur only very short zooids, and that, for instance, a whole colony from Seaforth (the small one) consists of such small zooids.

The number of the branchial tentacles (in no case counted exactly) seems to be smaller than in the original specimen, perhaps sometimes only 6 or 8 (?). They are very distant from one another.

The atrial languets, which in the New Zealand specimens are simple, trifid, or rarely bifid, are, in the colonies from the Cape as in that from the Red Sea, mostly simply tongue-shaped, rarely two by the side of each other, and very seldom trifid with a larger central tongue. The alimentary tract forms a simple, not a twisted loop (in the closely allied *A. circulatum*, Hartmr. (1912, p. 349), this loop is twisted through 180°).

The stomach is externally quite smooth or nearly smooth, its folds being very prominent on the inner surface. The number of the folds is very variable. In general I counted 25 or 26 in the specimens from the Cape Province, but once in a zooid from St. James as many as 29. By this number the zooid links with the var. *ptychodes* from New Zealand, which is characterised by the possession of 29 to 32 folds in the stomach. It is therefore doubtful whether the separation of this variety is justified. In general the extent of numerical variation increases in the higher regions of the scale. Only one species of *Amaroucium* has an equally large number of folds in the stomach, probably even more, and that is *A. circulatum*, Hartmeyer. In the somewhat schematic figure (1912, Pl. XLIV, fig. 6) there are seen 17 folds on the one visible side of the stomach, and in reality their number must be regarded as still greater, for Hartmeyer says in the note on the figure that in reality the folds are placed more closely than in the schematic figure. If there are nearly as many folds on the other invisible side, the number must be decidedly greater. In another respect the stomach of *A. circulatum* also differs from that of *A. erythraeum*. In the latter there rarely occurs a shortened or a bifurcated fold, in the former the folds are rather regularly divided into two shorter ones.

Sigillina (*Hyperiodistoma*) *illota* (Sluit.).

1898. *Distoma illotum*, Sluiter, 1898, p. 16, Pl. I, fig. 3, Pl. III, fig. 7.

1912. *Polycitor illotus*, Hartmeyer, 1912, p. 303, Pl. XXXVIII, fig. 2, Pl. XLIII, fig. 5.

1930. *Sigillina* (*Hyperiodistoma*) (*illota*), Michaelsen, 1930, p. 491.

Locality.—False Bay, Seaforth, under stones and overhanging rocks; 11/6/1932.

Remarks.—In referring the specimens from Seaforth to Sluiter's species, I am supposing, as Hartmeyer did, that Sluiter's description is not quite correct. Sluiter does not mention a post-abdominal appendix, traversed by an epicardial tube, which is generally present in my specimens as well as in those of Hartmeyer, and which measures at its greatest, 18 mm. (according to Hartmeyer, 15 mm.). Often this post-abdominal appendix is shorter or very short—sometimes even rudimentary, limited to a short swelling in the hinder part of the abdomen, and made opaque by being filled with mesenchyme cells. In the case under discussion the post-abdominal portion of the body has a very small translucent finger-shaped

appendix, not occupied (or not yet occupied?) by an epicardial tube. Sometimes there are even two such appendices.

The alimentary canal, in my material, is not quite as simple as Sluiter and Hartmeyer described it. In well-extended zooids (and only in these) there follows, after the stomach (which is quite smooth, both externally and internally, and is somewhat shortened dorsally), a sharply marked off conical posterior stomach, and then an oval glandular stomach. The sharply marked off intestine begins with an expansion, often with a pair of distinct swellings at each side of the entrance of the glandular stomach, recalling the bifid anterior end of the intestine in *Synoicum suesanum*, Mich. (1920, p. 3, Pl., fig. 1) and allied species (*loc. cit.*, p. 30). But this bifurcation is not always formed in the present species, and sometimes the anterior end of the intestine, even in well-expanded zooids, is quite simple. In strongly contracted zooids there is nothing to be seen of these characteristic parts between the stomach and the intestine.

Reproductive Organs.—In Hartmeyer's specimens there were no reproductive organs present, and Sluiter remarks only that the gonads are placed at the side of the alimentary canal and that incubatory pouches are wanting. I can confirm the first statement, but I must restrict the latter, which proves to be correct only in certain sexual conditions. Most of my specimens lack reproductive organs, but some few show two different states of sexual development. The first state is seen only in one zooid among the very many examined. This zooid appears to be a female, and had a rather large ovary on the inner side of the body-wall, in the region of the intestinal loop, somewhat behind the region of the stomach. Some of the ova seemed to be nearly mature: they contained masses of yolk, and had a diameter of about 0·06 mm. An oviduct could not be recognised. Other zooids had male organs. A rather small testis, in the form of a rose-diamond, with some pear-shaped testicular follicles, is placed (like the ovary in the female zooid) on the inner side of the body-wall in the region of the intestinal loop, somewhat behind the region of the stomach. A relatively rather thick sperm duct, filled with sperm masses, runs from the region of the testicle straight through the abdomen and into the thorax as far as the anterior part of the latter. I could not recognise the hinder end of the sperm duct, which ultimately became very thin, nor could I see its connection with the testis; therefore I cannot say whether the hinder end of this duct is straight or curved. Many zooids bear an incubatory pouch, which, when fully developed, is about $1\frac{1}{2}$ mm. long and 1 mm. wide, with an oval contour, convex on the outer side, flattened on the inner, in adjustment to the form of the dorsal side of the thorax. It has mostly fused with the thorax, but is occasionally free, attached to the thorax only at its anterior end, where it enters the atrial chamber of the thorax just behind the atrial siphon. The hinder part of the brood-pouch, about a quarter of its whole length, freely overlaps the hinder end of the thorax. Each brood-pouch contains a single embryo. It is remarkable that the zooid, with an apparently mature ovary, had no brood-pouch, which, on the other hand, was present in all zooids with male organs. We must, therefore, assume that the zooids are hermaphrodite, and for part of their sexual development unisexual, presumably proterogynous.

Sigillina (*Eudistoma*) *rhodopyge* (Sluit.), f. *kauderni* (Mich.).

Synonymy and literature of f. kauderni.

1921. *Polycitor* (*Eudistoma*) *kauderni*, Michaelsen, 1921, p. 9, Pl. I, figs. 5–7.

Synonymy and literature of f. typica.

1898. *Distoma rhodopyge* + *D. modestum*, Sluiter, 1898, p. 12, Pl. I, fig. 2; Pl. III, figs. 5A and 6; p. 18, Pl. I, fig. 5 : Pl. III, fig. 8.
1909. *Polycitor* (*Eudistoma*) *rhodopyge* + *P.* (*Eu.*) *modestum*, Hartmeyer, 1909, pp. 1432 and 1432.
1919. *Polycitor* (*Eudistoma*) *rhodopyge* + *P.* (*Eu.*) *modestum*, Michaelsen, 1921, p. 16 + p. 16.

Localities of f. kauderni.—False Bay, Seaforth, under stones and overhanging rocks; 11/6/1932. Still Bay, under stones, 19, 23, and 25/1/1932.

Remarks.—The examination of a richer material of this notoriously variable species confirms me in the opinion that the difference in the shape of the colony is of little systematic importance. I therefore unite *Distoma modestum*, Sluit., completely with *D. rhodopyge*, Sluit. It seems to be somewhat otherwise with the pigmentation of the colony and of the zooids. In the typical form of *Sigillina* (*Eudistoma*) *rhodopyge*, including the synonymous species "*modesta*," the mantle contains many cells with red pigment, and the zooids have a black pigmentation. These pigmentations do not vanish after preservation of the specimens in spirit or formalin. In the var. *kauderni* the zooids lack pigmentation, and in the mantle there occur only pale grey rounded cells. The notes of the collector: "no special colour"; "colourless"; "dusky yellowish-grey," show that this paleness of the specimens in question is not due to the influence of the preserving fluid. The difference in the colouring is adequately expressed systematically if we separate the different groups as "formae."

Sigillina (*Eudistoma*) *coerulea* (Sluit.)?.

? 1898. *Distoma coerulum*, Sluiter, 1898, p. 14, Pl. II, fig. 4 : Pl. III, fig. 11.

Locality.—Still Bay, under a stone; 15/1/1932 (a very small, weak colony).

Remarks.—As the present material is too scanty, and not well preserved, I cannot publish my determination without a sign of interrogation. What is recognisable in my specimen agrees with the description of this species, especially the colouring, which in the preserved material is a blackish-blue, depending on very dark pigment cells, especially densely crowded in the outer layer of the mantle. The living specimen was, according to the collector, "blackish with bright blue markings." The present specimen agrees with the type-specimen in the shape of the zooid, as well as in the shape and position of the stomach.

Distaplia capensis, n. sp.

Localities.—Still Bay, under stones in pools, 19, 22, and 25/1/1932. False Bay, Seaforth, under stones and overhanging rocks, 11/6/1932.

The present colonies belong to a species of *Distaplia* very closely allied

to *D. fasmeriana*, Mich. (1924, p. 297, text-figs. 1–10), from Stewart Island near New Zealand. One might be tempted to make it a "varietas" of the New Zealand species, but since the gonads and their relations are unknown in *D. fasmeriana*, and may be very different from those of *D. capensis*, and as I wish to avoid systematic complications, I prefer to describe the latter as a new species.

Description: Form and Dimensions of the Colony.—The specimens from the two different localities represent different states in the development of the colony. The two colonies from Seaforth seem to be fully adult, not only perfect in shape and size, but also sexually mature. On the other hand the numerous colonies from Still Bay are still small and imperfect, and show no trace of sexual organs. The smaller of the two colonies from Seaforth represents a single cormidium, perhaps only a piece torn off from a multiple colony; the larger colony consists of two (or three) cormidia, coalesced at the base (of three cormidia if a small piece of the head of one cormidium, separated only by a deep incision, be counted as a perfect cormidium). The cormidia are irregularly fan-shaped. Their head, containing very numerous zooids, is broadly and rather thickly kidney-shaped. The "hilus" of the head is occupied by the broad distal part of the stalk, which is bare of zooids, and narrows towards the base. The two cormidia of the colony in question are in contact by the broad sides of their heads, their stalks being almost completely coalesced. The heads of these two cormidia are almost equally (about 80 mm.) broad, 25 mm. high, and 15 mm. thick. The stalk is not marked off sharply from the head, but is indicated distinctly by the abrupt beginning of the region of zooids. The small colonies from Still Bay each represent only a single cormidium. Their head is not distinctly fan-shaped; it is usually cylindrical, at the most somewhat flattened and a little broadened. Their stalk is narrower and shorter than the head, sometimes very short and broad. (In *D. fasmeriana* the stalk is, in general, longer, rarely somewhat shorter than the head, the head usually cylindrical, rarely somewhat flattened.)

Consistency of the Colony.—The heads are very soft, almost jelly-like, but attached and kept in shape by a very tough and thin skin. The stalk is somewhat firmer, sometimes almost cartilaginous.

Colour of the Colony.—In the living condition, according to the collector, "crimson in places" (specimens from Still Bay) or of "no special colour" (specimens from Seaforth). In the specimens preserved in formalin the head is, in general, dark grey, with paler zooids shining through, and darker cloacal chambers filled with blackish excreta. In the larger colony from Seaforth may be seen even now, in parts, a slight reddish tint: in the living state it may have been red in parts like the specimens from Still Bay.

The surface of the colony is, in general, plain and smooth, quite clean, without incrustation of foreign particles.

The arrangement of the zooids in groups is, in very small young colonies, sometimes distinctly *Sycozoa*-like, though with many irregularities. In these colonies the zooids are placed in double rows, in regularly formed specimens running from the base of the head to its apex. In such a regular arrangement the two rows of a group are separated by a narrow space containing a translucent longitudinal cloacal channel, whilst the

adjacent rows of two neighbouring groups are closer to one another than the two rows belonging to the same group. In one of the small colonies these double rows end near the apices of three small mounds on the rounded top of the head. Presumably the cloacal channels of these double rows discharge through cloacal apertures on the apices of these mounds. Such regular groups of zooids are only rarely seen in the present material, and are in every case combined with irregularly placed zooids or groups of zooids. The large adult colonies from Seaforth, as well as some small ones from Still Bay, show in general a less *Sycozoa*-like arrangement of the zooids, which are here mostly irregularly and densely crowded, leaving no spaces for cloacal channels to shine through. As in each dense group of equally large discs, so also in this conglomeration of zooids there are formed straight or curved rows crossing one another in a seemingly regular manner: nevertheless, these cannot be taken for typical groups or systems of zooids. In these colonies only round the marginal part at the base of the head, where the zooids are less densely crowded, are to be seen some typical groups of zooids, small oval and circular groups or somewhat longer double rows, running irregularly and not in a meridional direction. *D. capensis*, according to this, is a species showing a *Sycozoa*-like arrangement of the zooids only in a young state of the colony, this arrangement passing into an irregular one as the colonies grow older. (In *D. fasmeriana* this *Sycozoa*-like state seems to be retained until the colony is very much older.)

The mantle is very soft, almost jelly-like in the head. It contains many bladder-cells of about 0·025 mm. diameter, and with very thin walls which are not visible in the present material, presumably in consequence of its unfavourable state of preservation. These bladder-cells have the appearance of empty cavities. The intermediate space contains many minute spindle-cells and stellate-cells. In a very thin, not sharply delimited cortical layer, at the surface of the head, the bladder-cells are absent and, in consequence, this superficial layer forms a tough skin.

The zooids are, in the full-grown condition, without the vascular appendix, about 2 to nearly 3 mm. long. The thorax is somewhat flattened at the sides, longer than high, and higher than broad, almost flatly truncated, at both ends, with rounded corners. The waist arises from the dorsal part of the hinder border of the thorax. It is rather slender, much shorter than the thorax or the abdomen, and sharply marked off at both ends. The abdomen is sac-shaped, flattened at the sides, and nearly circular. From the middle of its hinder border arises an uncommonly long, rather sharply marked off vascular appendix, a very thin double tube, swelling at its free end into a pear-shaped, thick-walled bladder with seemingly simple undivided lumen. In uninjured isolated zooids the appendix measured several times the length of the body of the zooid.

The branchial siphon arises from the middle of the anterior wall of the thorax, from which it is sharply marked off. The siphon is cylindrical, or in the middle of its length somewhat narrowed, a little less long than broad, crown-shaped, ending at the apex in six regular, shortly triangular lobes with rounded apices.

The atrial siphon is very characteristically shaped, but in certain respects variable. I assume as normal the following shape: A broad, thin-walled

tube with its base occupying nearly the whole breadth of the dorsal side of the thorax, cleft by a deep incision on each side, nearly as far as its base, and thereby divided into a fore-lip and a hinder-lip, and on the whole looking like a broadly gaping muzzle. The fore-lip is, in general, not larger than the hinder-lip, and not distinctly elongate. It is hardly to be classed as an atrial languet. Both lips have a smooth margin without lobules. A variety of this normal shape is sometimes caused by a shortening of one of the two incisions, the whole siphon then looking like a wry mouth. The contour of the lips is not always uniformly rounded, but has sometimes the shape of a trapezium or of a rectangle with rounded corners, unless there has occurred a post-mortem distortion. Rarely the hinder-lip is distinctly shorter than the fore-lip, which latter then gives the impression of an atrial languet, but of a very short one. (In *D. fasmeriana* the hinder-lip of the atrial siphon is always much shorter than the fore-lip, often hardly projecting. On the other hand the fore-lip is always long, forming a distinct atrial languet, and this atrial languet usually bears at its distal margin several more or less regular lobules, the number of which may be somewhat reduced, rarely even to one, so that the atrial languet appears simply slender triangular.)

Branchial tentacles rather regularly hexamerously arranged, slender, finger-shaped, always 6 large ones of a first order and 6 smaller ones of a second order. Often I thought I could see, between these tentacles of the first and second order, single minute tentacles of a third order, but these were very indistinct, and at least never occurred in full number. (In *D. fasmeriana* there are 12 tentacles of the first and 12 of the second order, and irregularly (?) distributed tentacles of a third order, in all, 24 or more.)

Branchial sac truncated at the hinder end, closed by a retropharyngeal furrow. It has 4 zones of stigmata, each zone being divided by a parastigmatic transverse vessel. Stigmata long, with parallel borders, about 7–9 in a half-zone, as seen in an optical sagittal section. The half-zone not marked by the dorsal languets, which do not lie in the mid-dorsal line, but are displaced a remarkable distance to the right side. Therefore the number of stigmata to the left of the dorsal languets is greater than that to the right of them (for example, 11 + 5 instead of 8 + 8, as generally noted). (In *D. fasmeriana* about 20 stigmata are present in a half-zone; there are thus more than in *D. capensis*.)

Alimentary Canal.—This forms a simple, not a twisted loop, whose limbs are adjacent in the waist and form a circle in the abdomen. Oesophagus straight in the waist, turning ventrally in the abdomen to reach the dorsal side of the stomach, which occupies the greater part of the anterior ventral quarter of the circular loop. Stomach short dorsally, long ventrally. The entrance of the oesophagus, lying a considerable distance behind the anterior pole of the stomach on its dorsal side, forms a distinct cardiac swelling; whilst the beginning of the after-stomach is simple, not forming a pyloric swelling. The epithelium of the stomach is thrown into about 14–16 longitudinal folds, the median ventral ones lengthened, the median dorsal ones shortened in relation to the shape of the stomach. These folds, marking the meridians of the stomach, sometimes show irregularities; an abnormal abrupt shortening or a bifurcation. The outer

side of the stomach is rarely nearly smooth; usually the interspaces between the folds cause more or less shallow external longitudinal furrows. The intestinal gland discharges into the dorsal side of the stomach a little way behind the middle. The duct of the gland runs out directly between stomach and intestine, and does not branch before reaching the intestine. The straight and simple part of the duct widens, in or near the middle, to a sharply marked off oval, or sometimes almost globular, bladder-like reservoir about 0·07 mm. long and 0·06 mm. wide. The ectal and the ental parts of the unbranched duct, *i.e.* the parts before and behind the reservoir, are nearly of the same length. (In *D. fasmeriana* the reservoir is quite globular, about 0·065 mm. thick, and the ectal part of the duct between reservoir and stomach is very short, almost completely hidden between the outer furrows of the stomach.) The after-stomach is small, almost cylindrical, sharply marked off at both ends. The glandular stomach is also well marked off, very short, several times wider than long, and looks like a narrow circular fold. (In the description of *D. fasmeriana* the two latter parts of the alimentary canal are united under the term "Mitteldarm".) The intestine (in the description of *D. fasmeriana* termed the "Enddarm") is moderately thick, sausage-shaped. It forms the returning part of the intestinal loop in the abdomen and in the waist, as well as in a considerable part of the thorax. As rectum I denominate a very short terminal part of the alimentary canal, opposite the middle of the branchial sac. This rectum is funnel-shaped, sharply marked off from the intestine by a neck-like constriction. It ends in the atrial chamber in two broad, smooth-edged anal lips.

Sexual organs were seen only in the two large colonies from Seaforth, and these were male. In *D. capensis* therefore, as in *D. fasmeriana*, the colonies are evidently unisexual. The testis has the shape of a rose-diamond; it is composed of about 10–14 stoutly pear-shaped testicular vesicles. It is placed wholly in the cavity of the abdomen, and covers, in full development, the whole concavity of the intestinal loop, somewhat overlapping its inner margin dorsally, whilst ventrally it hardly reaches the intestine. Female organs and incubatory pouches were detected in none of the colonies, but it must be noted that not all the small specimens from Still Bay were examined.

Remarks.—As is seen from the foregoing, *D. capensis* is distinguished from *D. fasmeriana* by several more or less important characters, namely, by the muzzle-shaped atrial siphon (intermediates rarely seen), by the smaller number of branchial tentacles (not very essential?), and of stigmata in the branchial sac, and above all by the much greater length of the ectal part of the duct of the intestinal gland, between the stomach and the reservoir. I cannot lay very great stress upon the arrangement of the zooids. It remains doubtful whether there is a difference in the formation of the sexual organs, as we know only the male organs from *D. capensis*, and from *D. fasmeriana* only a part of the female ones, indeed, only the incubatory pouches. Hereafter greater differences may be found. Doubtless these two species are nearly allied to one another, differing from all other known species by the shape of the stomach with its longitudinal folds.

Didemnum stilense, n. sp.

(Fig. 2.)

Locality.—Still Bay, under stones; 5/1/1932.

Description: Shape, Consistency, and Fixation of the Colony.—The colony is a quite irregular sheet, about 9 mm. thick, weak and tough, which was attached by its whole underside to a flat stone, incrusting the latter.

Appearance of the colony yellowish-white in the specimen preserved in formalin, "white" in the living condition, according to the collector.

Surface of the colony smooth in general, but slightly roughened by the prominences of the zooids, which are often like low warts. The zooids are distributed quite irregularly on the surface, their external walls not sharply delimited, about 0·3 mm. broad, flat or slightly prominent as low warts. Branchial orifices indistinct when fully open, presumably with six rays (not distinguished). Cloacal apertures not seen.

Mantle rather tough, cartilaginous. The outer layer forms a cortex of *ca.* 0·1 mm. thickness, lacking in general the calcareous spicules, being composed principally of bladder-cells. The bladder-cells are remarkable for their variation in shape and thickness. They are 0·03 to 0·05 mm. across, sometimes globular, sometimes oval, or of irregular shape when pressed against each other by dense crowding. In the outer layer, the cortex, they are mostly densely crowded, only arranged somewhat less closely in places. In the inner layers of the mantle they are scanty, but in the basal layer they again become numerous, being in parts densely crowded. The calcareous spicules have the shape of a "Morgenstern". They are globular, furnished with very numerous short, conical spines; about 20–30 are to be seen in an optical cross-section arising from the circular profile. Even the most minute spicules, in the interior of the lateral organs of the thorax, hardly 0·01 mm. across, show traces of these spines. The calcareous spicules are, in general, absent from the cortex, and only in the immediate vicinity of the branchial siphons do they ascend as far as the surface of the mantle. They occur principally, often in dense formation, in the middle layers of the mantle. The mantle contains also numerous spindle-cells and a few small, apparently unpigmented globular-cells; in the basal layer, moreover, are dense groups of varying size of deeply coloured granules, presumably renal secretions.

The cloacal chambers are, in general, limited to a thin layer somewhat beneath the cortex; it corresponds to the middles of the thoraces, or rather to the atrial orifices. Here they form a simple labyrinth of cloacal channels and flat cloacal cavities, probably ascending to the surface only at the cloacal apertures (which were not distinguished).

The zooids are placed very irregularly, being arranged in some places more or less exactly at right angles to the surface, in others obliquely; they are often distorted. They are about 0·8 mm. long.

The thorax, in the present material, is always very much shrunken; it is of oval form, somewhat longer than broad, and about as broad as thick. The sharply marked off branchial siphon is crown-shaped, somewhat broader than long, slightly narrower in the middle of its length. It terminates in six regularly placed slender lobes with intermediate concave

excisions. The atrial orifice is a rather large opening in the middle of the dorsal side. Its margin is not quite even, but no siphon is formed. In one zooid I could recognise at one side, a little behind the thorax, a thoracic lateral organ (fig. 2). It is quite external, its base hardly making a recognisable impression in the direction of the peribranchial chamber. It is sac-shaped, sloping backwards, strongly vaulted at its anterior end, about 0·07 mm. long and 0·03 mm. high. Its opening into the mass of the mantle (not recognised) seems to lie at the anterior end, where one finds the largest calcareous spicules, about 0·08 mm. across, and seemingly ready to slip out. This organ is densely packed with small and minute calcareous spicules.

The muscular retractor arising from the hinder end of the thorax is slender, a little shorter than the thorax, ending in a thin, thread-like tip, fixed by a short attachment to the anterior part of the waist. The waist is sharply marked at both ends, thin, cylindrical, much shorter than the thorax, sharply constricted a little before its hinder end.

The abdomen is broadly sac-shaped, almost spherical, and in zooids without sexual organs is strongly flattened at both sides. In zooids with sexual organs it is much vaulted at the side bearing these organs.

The internal organisation of the thorax could be made out only as regards a few points, by reason of its shrinkage. As I could make out 3 dorsal languets in a few zooids, we may conclude that there are 4 zones of stigmata.

The alimentary canal forms, in the abdomen, a broad loop curved into a circle, but partly coming out of the general plane. The stomach is almost globular, with the wall smooth externally and internally, and with small cardiac- and pyloric-swellings. The after-stomach is small, at first narrow, then widening to a funnel. The glandular stomach is spindle-shaped, sharply marked at both ends. When they are filled with excreta the shape of these parts of the alimentary canal is not recognisable. The intestine is simple, cylindrical.

Sexual Apparatus.—The zooids are hermaphrodite. Ovary and testis lie closely pressed against one another at one side of the body-wall, pressing this outwards. The ovary usually contains one egg-cell much exceeding the others in size. The relatively very large testis consists of a single, simple, bulb-shaped testicular vesicle. From the middle of the outer side of the latter arises the sperm-duct, which forms a large number (8–12) of spiral windings. These windings are closely packed together, and thus form a *caput* which covers nearly the whole outer side of the testicular vesicle, leaving free only the central part of it, internal to the first small convolution. In its further course the sperm-duct goes direct through the abdomen, the waist, and the greater part of the thorax as far as the atrial chamber of the latter. The ental end of the sperm-duct, and a short part of the first convolution, are very thin. In the rest of the convoluted part it is moderately and equally thick. Its free ectal part, running forwards, is very thin for a little way at both ends, but swollen into a rather wide tube in its middle part. This middle part, being filled with sperm-masses, is wider than the twisted part, and gives the impression of a sperm vesicle.

Discussion.—Because of our uncertainty as to the limits of variability, and because of the occurrence of so many species insufficiently described,

it is hardly possible to say whether *D. stilensis* is indeed a new species, or whether it should be identified with any older species. It seems to be most closely allied to *D. helgolandicum*, Mich. (1921A, p. 118), from northern seas, but it is distinguished from that species by the shape of the calcareous spicules, and of the thoracic lateral organs; presumably also by the swelling of the sperm-duct to form a sperm vesicle.

Didemnum seychellense, Mich.

1919. *Didemnum psammatodes*, Sluit., var. *seychellense*, Michaelsen (nom. nud.), 1919, p. 12.

1920. *Didemnum psammatodes*, Sluit., var. *seychellense*, Michaelsen, 1920, p. 28.

Locality.—False Bay, Seaforth; under a stone; 11/6/1932.

The study of this new material, together with a re-examination of the old, has embarrassed me very much. It showed that my notes about the cloacal chambers, and about the embedding of faecal masses in them are probably erroneous (see below). The examination showed, furthermore, that the form "*seychellense*" differed in two remarkable points from all the other forms of *D. psammatodes*. Therefore I prefer to separate it from that species, and to regard it as a distinct one.

As the original description is only scanty, and in one point probably even incorrect, I give here a complete description, considering the new specimens as well as the old ones.

Description: Shape and Fixation of the Colony.—The colonies are cartilaginous crusts, in general $1\frac{1}{2}$ mm. thick, attached to stones and similar objects by the whole underside. In the new colony from Seaforth this crust bears several high dome-shaped prominences, which are not simply thickenings, but are formed by the embedding of mussels of the genus *Modiolaria*. These mussel-galls have a slit-shaped opening which may be mistaken for a cloacal aperture.

Appearance of the colony in the living condition, according to the collector: "opaque, pale orange." The colonies preserved in spirit and formalin are, in general, milky-white; examined with a magnifying glass there is seen a translucent grey tissue with opaque white zooids embedded in it.

The surface of the colony, apart from the prominences of the mussel-galls, is rather smooth., The external zooidal plates are flat, not very prominent, circular, about $\frac{1}{3}$ mm. wide, without a distinct margin. In general they are irregularly distributed, but in places they form small circles and ovals or somewhat irregular double rows. Probably these arrangements are not to be regarded as zooidal systems. The branchial apertures in the middles of the external zooidal plates are of irregular form, not regularly radial. Cloacal apertures are not visible, and probably not present.

Mantle cartilaginous, with a cortex at the surface, principally formed by bladder-cells. This cortex is separated from the middle layers by a thin, harder, subcortical layer, without bladder-cells, but containing many calcareous spicules. Bladder-cells of variable diameter, at the most about 0·05 mm. across, with thin walls colouring intensively in haematoxylin-

eosin. The bladder-cells are in some places densely crowded, compressing one another, principally in the external cortical layer, and in the innermost basal layers. They are arranged less densely in the middle layer, and here their shape is consequently more regularly globular or oval. The calcareous spicules have the shape of a "Morgenstern". They are globular, furnished with numerous regularly arranged spines. These thorns are slender conical, or shorter and thicker conical, or even almost dome-shaped. Their number is somewhat variable, usually very large; as many as thirty may project from the circular profile. Mostly this number is about fourteen, very rarely considerably smaller. In one case it was only six. The dimensions of the calcareous spicules are rather small. They are mostly about 0·023 mm. across. Some hypertrophied spicules attain a thickness of about 0·030 mm. in the colony from Seaforth, and even of 0·042 mm. in the original colony. The calcareous spicules are, in general, absent from the superficial cortical layer, reaching the surface only in the immediate vicinity of the zooids, and this only in some cases. The spicules are densely crowded in the thin subcortical layer, becoming scantier in the middle layers, and particularly scanty in the basal layer. The mantle contains, furthermore, a great many spindle-cells, and small colourless globular cells with coarsely granular cell-body. These are no typical pigment cells. Finally, there are found embedded in all layers of the mantle, with the exception of the cortex, sparsely distributed oval faecal masses. Mostly these occur singly, but once I saw a few forming a close horizontal row running out from an atrial orifice. In my former description of this Didemnid from the Indian Ocean, I said that faecal masses occurred only in cloacal chambers (1920, p. 28). This note is probably based upon an erroneous observation. I have now examined a large piece of the new material from Seaforth, as well as from the original material from the Seychelles, in complete series of sections. I can assert that at least in these two specimens there is no trace of any cloacal chamber. The tissue of the mantle is attached direct to the dorsal wall of the thorax, thereby completely covering the atrial aperture. The entering of faecal masses from the thoracic atrial chamber into the tissue of the mantle can only be direct, without interposition of cloacal chambers. If in this way some faecal masses enter the mantle-tissue close together, they then form, before dispersing in the mantle, a close horizontal row. The probable mistake in my former paper may be explained as follows: The material was over-hardened. The sections were rather fragile. In flattening the sections they are inclined to break along the line of least resistance, and this is the close row of soft and fragile faecal masses. Presumably a cleft caused in this way, alongside the row of faecal masses, was mistaken by me for a cloacal channel. If this is not the correct interpretation, there is only one other explanation—we must assume that the specimens without any cloacal chamber represent only a temporary state of rest, during which the activity of feeding and of expelling faeces is interrupted. Perhaps a peculiarity of the specimen from Seaforth supports the latter interpretation. In this specimen the activity of the alimentary tract does seem to be interrupted temporarily. In all of the numerous zooids examined, the alimentary canal was quite empty, whilst in the specimen from the Seychelle Islands the intestine contained faecal masses in the ordinary way, in spite of the absence of cloacal chambers.

The zooids have a length of about 1 mm.

The thorax is longer than deep, and deeper than wide. The branchial siphon is cylindrical, straight, about as long as wide. Its ectal margin has six regular, but very short, incisions, related to six very short, broad convexities, which can hardly be called marginal lappets. This absence of well-formed marginal lappets may correspond with the absence of a conspicuous and regular radiation of the branchial orifices at the surface of the colony. The atrial orifice is placed in the middle of the dorsal side of the thorax. It is a simple, not very large, opening, which usually seems to be closed. Presumably it opens only occasionally whilst expelling a faecal mass. The thoracic lateral organs are very indistinct in the new specimens as well as in the old ones; they are quite external, but rather large. They are marked by a vague oval flattening, which occupies the greater part of the lateral sides of the thorax. The muscular retractor at the hinder end of the thorax is rather short, generally only a quarter or a third as long as the thorax, occasionally somewhat longer, but never attaining the length of the thorax. Only in zooids with a very much shrunken thorax does its length approach that of the thorax. In this shortness of the retractor *D. seychellense* differs from *D. psammatodes*, Sluit., and all its varieties, in which it is at least as long as the thorax, and usually longer.

The waist is about half as long as the thorax, sharply marked off at both ends, sharply constricted about the middle. It has the appearance of two slender cones with joined tips.

The abdomen has the shape of a sac flattened at its sides, with almost circular contour. There are no vascular appendages.

The branchial tentacles appear to be arranged according to a sixfold system. In a zooid from the Seaforth specimen I saw 6 large tentacles of order one, and 6 half as long of order two. It was doubtful whether there were very small, perhaps wart-like, tentacles of a third order between those of orders one and two. If such were normally present the total number of tentacles would be 24. In a zooid of the type-specimen from the Seychelle Islands I counted about 24 tentacles.

The branchial sac is longer than wide, and wider than high. It bears 3 rather blunt dorsal languets and 4 zones of stigmata. There were usually 6, sometimes only 5 longitudinal stigmata in a half-zone.

The alimentary canal forms in the abdomen a simple, rather regular circular loop. The stomach is rounded box-shaped, nearly globular. Its wall is smooth, both internally and externally. After-stomach and glandular stomach sharply marked off, the former conical, the latter trumpet-shaped. Intestine cylindrical.

Sexual Apparatus.—The zooids are mostly (always?) hermaphrodite. The testis and the ovary are closely pressed against one another, and placed at one side of the abdomen, which is strongly vaulted by them. Ovary mostly with one large egg-cell, which far surpasses the other egg-cells, which are very small. The testis consists of a simple, flattened, globular vesicle. Sperm-duct forming about eight regular spiral coils. These coils, closely apposed to one another, cover the external side of the vesicle, leaving free only its central part, internal to the first coil, from the centre of which the sperm-duct proceeds. The sperm-duct is moderately and

equally thick in all its coils, with the exception of the first one, which is somewhat thinner. Also the ectal part of the duct, going straight to the thorax, has no swelling which might be regarded as a sperm vesicle.

Remark.—*D. seychellense* differs from *D. psammatodes* principally by the shortness of its thoracic retractor, and presumably by the absence of cloacal chambers.

Didemnum velans, Mich.

1920. *Didemnum velans*, Michaelsen, 1920, p. 41, text-fig. 4.

Localities.—Still Bay, 19/1/1932; Preekstoel, near Still Bay, 22/1/1932. Under stones in pools.

Remarks.—Colour of the living specimens, according to the collector: "opaque white"; "greyish white."

Leptoclinides capensis, n. sp.

(Fig. 3.)

Locality.—Preekstoel, near Still Bay, under stones; 10/1/1932.

Description: Shape and Mode of Attachment of the Colony.—The present material is an almost complete colony which has apparently adhered as a thin crust to the underside of a stone. It is a weak, ragged plate of irregular outline, about $1\frac{1}{2}$–2 mm. thick.

The colour of the living specimen was, according to the collector, "white with transparent spots." The preserved specimen is pale grey with whitish spots.

The surface of the colony (fig. 3) is flat and rather smooth, almost polished. The superficial areas of the zooids are circular whitish spots, about $\frac{1}{3}$ mm. across or smaller, with vague margin, and with a darker central branchial orifice, irregularly rayed (tri-radiate?) or slit-shaped, each placed on a minute elevation, rendered pure white by the aggregation of calcareous spicules. The distance between two neighbouring zooid areas is about $\frac{1}{2}$ to $\frac{2}{3}$ mm. These areas are, in part, distributed fairly evenly over the surface of the colony, in part, somewhat more sparsely. They are arranged partly in a quincuncial manner, partly in straight or curved parallel lines which in places form a sieve-like pattern by regular crossings. Near the margin of the colony I saw a very characteristic cloacal aperture on an almost circular paler area about $2\frac{1}{2}$ mm. across; the area was devoid of zooids. The aperture formed a darker triangular central spot, perforating the thin sheet which covered the cloacal cavity like a diaphragm. The neighbouring zooids were crowded round this cloacal field in a regular manner, and therefore it was surrounded by a dense circle of zooid spots—in this case, twenty-one of them.

The mantle is weakly cartilaginous. It contains in almost all layers, from the surface to the deepest layer, densely crowded bladder-cells of about 0·035 mm. diameter, which mutually flatten one another. In the intermediate spaces of the mantle are scattered many minute spindle-cells. About 0·12 mm. beneath the surface of the colony there occurs a regular subcortical layer of about 0·03 mm. thickness, devoid of bladder-cells, and, in consequence, tougher than the mantle in general. In the immediate vicinity of the zooids this subcortical layer rises to the surface of the colony.

The toughness of the subcortex is strengthened by the inclusion of calcareous spicules. These form a regular simple stratum, in general rather sparsely arranged, somewhat more densely crowded around the zooids. Apart from this stratum calcareous spicules occur only in the thoracic lateral organs, and in the parts of the mantle above these organs, near the zooids. The calcareous spicules have the shape of a star with rather slender spines, rounded at the apex, and about $\frac{1}{2}$ to $\frac{2}{3}$ as long as the middle part of the spicule. There are about eight spines round the profile of the spicule, which from apex to apex is about 0·04 mm. across; many are much smaller. The cortex above the subcortical layer is crowded with bladder-cells like the mantle in general, and is occupied at the surface by minute black, irregularly beam-shaped, bodies, which also occur at the surface of the cloacal chambers, and which I believe to be extraneous materials or secretions of the ascidian. The cloacal chambers consist of a rambling labyrinth of cloacal canals about 0·5 mm. wide, running in the bottom layer, and separated from the underside of the colony by a layer about 0·15 mm. thick. I assume that this labyrinth sends a connecting canal into the surface layer, and to the cloacal cavity beneath the cloacal aperture.

The zooids in the present material are very much shrivelled, especially in the thoracic part. The zooids were formerly, to judge from the now partly empty, but not contracted zooidal cavity, about $1\frac{1}{2}$ mm. long, the greater part of this length occupied by the now shortened thorax. The zooids are rather straight, more or less exactly placed vertical to the surface of the colony, only the abdomen in some of the zooids entering the region of cloacal canals.

Thorax longer than wide, and wider than high, almost cylindrical; rounded at the ectal end. Branchial siphon rather long, tubular, sharply marked off from the thorax, more or less widened ectally, sometimes almost funnel-shaped, at the ectal end with six regular triangular lobes.

Atrial siphon shaped like an inverted funnel, with a broad base arising from the dorsal body-wall and, narrowing towards the ectal end, pointing obliquely towards the cloacal chambers. The atrial siphon is shorter or longer, according to the distance between its thorax and the cloacal labyrinth. It opens by a moderately large, smooth-edged circular aperture into a cloacal canal.

Thoracic lateral organs internal, in the hinder half of the thorax, minute sacs with a scarcely narrowed opening, the sacs projecting into the peribranchial chamber of the zooids. I saw in a carefully studied zooid only two calcareous spicules which apparently had attained full growth.

There was no trace of a *muscular retractor* in any of the many zooids examined.

The waist of the zooid is sharply marked off at both ends, rather long, sharply constricted in the middle, consisting of two slender conical portions, their points meeting together, and with a longitudinal furrow on each side.

The abdomen has the shape of a somewhat flattened sphere in mature zooids strongly vaulted at one side.

There were no *vascular appendices* in any of the many zooids examined.

Branchial tentacles when normally represented apparently 32, arranged according to the formula 1.3.2.3.1, in a regular circle.

Dorsal tubercle a low cone, apparently with a simple narrow perforation (not distinctly seen).

Branchial sac in all zooids examined completely shrivelled, presumably with 4 zones of stigmata. I believe that I saw 3 dorsal languets in one of the zooids, and from this I deduce the number of zones of stigmata.

Alimentary canal forming a simple, almost circular loop. Oesophagus slender, curved. Stomach almost globular, smooth-walled, with distinct internal swellings at the cardia and the pylorus. After-stomach and glandular stomach mostly well marked. Intestine sausage-shaped, rectum not distinctly recognised.

Sexual Apparatus.—Zooid hermaphrodite, or unisexual and male (proterogynous hermaphrodite?). Testis a simple vesicle of flattened globular shape, covering the circular concavity of the intestinal loop in the middle of one side. From the middle of the outer broad side of the testis arises a thin tubular sperm-duct, coiled in about six spiral coils, which cover the greater part of the middle of the outer broad side of the testis. The spiral coils of the sperm-duct are not always quite regular. In hermaphrodite zooids the ovary lies beside the testis.

Remarks.—The number of stigmatic zones is doubtful, and consequently also the position of the species; whether it belongs to *Leptoclinides* with 4 stigmatic zones or to *Trididemnum* with only 3 of them. The latter position is at least improbable since we do not know of any *Trididemnum* without a muscular retractor at the hinder end of the thorax, an organ never found in the known species of *Leptoclinides.*

L. capensis seems to be most closely allied to the boreal species *L. faeröerensis*, Bjerkan (1905, p. 20, Pl. III, figs. 4–8), the only known species of *Leptoclinides* with a simple testicular vesicle, whilst all the species living in the intermediate zones of the earth have compound testes. The genus *Leptoclinides* has, therefore, a distribution of the "bipolar" type.

L. faeröerensis differs from *L. capensis* in the shape of the colony, which is thick and fleshy, and also in the size of the thoracic lateral organs.

Corella eumyota, Transtedt.

Locality.—False Bay, Seaforth, under a stone; 11/6/1932.

Remarks.—A single torn specimen.

Dimensions.—Length about 80 mm., width about 40 mm.

Colour of the living animal, according to the collector, "translucent grey."

Appearance and shape very irregular, in adjustment to the irregular substratum, and on account of the attachment to and embedding in the mantle of foreign bodies of considerable size—for instance, stones as much as 20, 15, 14 mm. in diameter. The stones are, some of them, rather loosely cemented to the relatively thin mantle, and then fall off easily, leaving behind cavities on the mantle. Others are wholly embedded in the mantle and covered externally by mantle-tissue. As far as I know, such an incrustation of the mantle has as yet not been seen in this species.

Ascidia sydneiensis, Stimps.

Localities.—Still Bay (date?) and Preekstoel, under a stone, 10/1/1932 (from each locality 1 specimen); False Bay, Seaforth, 8/1/1932 (several specimens).

Remarks.—Appearance of the living animals according to the collector: "No special colour." The preserved animals are dirty grey, the intestine, filled with dark excreta, translucent dark grey.

Ascidia incrassata, Heller.

Locality.—Still Bay, under a stone in a pool; 17/1/1931.

Remarks.—Appearance of the living animal according to the collector: "translucent greenish."

Botrylloides leachi (Sav.).

Localities.—Table Bay, 11/4/1932 (1 colony). False Bay, Seaforth, 6/6/1932.

Remarks.—Colour of the living colony according to the collector: "blackish purple" (note in common for this species and the following one); of the preserved colony, dark purple-blue.

Botryllus magnicoecus (Hartmeyer).

Locality.—Table Bay, 11/4/1932 (1 colony).

Remarks.—Colour of the living colony according to the collector: "blackish purple" (note in common for the species and the foregoing), of the preserved colony: dark brownish-red, almost purple, a little lighter than the preserved *Botrylloides leachi* (Sav.).

Symplegma elegans (Q. and G.).

1834. *Distomus elegans*, Quoy et Gaimard, 1834, p. 623, atlas Pl. XCII, figs. 11–13.
1886. *Symplegma viride*, Herdman, 1886, p. 144, Pl. XVIII, figs. 7–14.
?1898. *Diandrocarpa monocarpa* (partim), Sluiter, 1898, p. 55, ?Pl. VII, fig. 6 (*a*, 7 ?, not figs. 5*a*, 8).
1904. *Diandrocarpa botryllopsis* + *D. monocarpa* + *D. brakenhielmi*, Michaelsen, 1904, pp. 43, 43, 50.

Further synonymy and literature see under:
1918. *Symplegma viride*, Michaelsen, 1918A, p. 101.
non 1912. *Chorizocarpa elegans*, Hartmeyer, 1912, p. 266.
nec 1915. *Chorizocarpa elegans*, Michaelsen, 1915, p. 413.

Localities.—Still Bay, under stones in pools at low water, 19/1/1932; Preekstoel, near Still Bay, 22/1/1932.

Great confusion has prevailed in the records of the compound Styelids or Polyzoines of the Cape Province, caused by two different mistakes. We must first clear up the older one. In the year 1895 Sluiter (1895, p. 183) noted a Polyzoine from Thursday Island in Torres Strait as *Synstyela incrustans* (Herdm.), and some years later (1898, p. 55) he described a Polyzoine from Sea Point near Cape Town as *Synstyela monocarpa* n. sp. Sluiter kindly sent me parts of the material from both localities. On examining these I discovered that the specimen supposed to have come from Sea Point belonged to the genus *Diandrocarpa* of Van Name (=

Symplegma, Herdm.), and did not correspond to the description of *Diandrocarpa monocarpa*, having 4 longitudinal vessels on each side of the branchial sac, whilst the specimen supposed to have come from Thursday Island belonged to a genus with only 3 longitudinal vessels on each side of the branchial sac, and which was later on called by me *Chorizocarpa* (1904, p. 92). This *Chorizocarpa* from Thursday Island (?) corresponded in general to the description of *Synstyela monocarpa*, Sluit., but Sluiter, to whom I pointed out in a letter the erroneous determination (as *Synstyela incrustans*, Herdm.), then described it in a short note (1900, p. 110) as *Synstyela michaelseni*, n. sp. I concluded that a mistake must have occurred —a mixing of the material from the two localities, or else of the notes about them. I believed that the *Chorizocarpa* came from Thursday Island and the *Diandrocarpa* (=*Symplegma*) from Sea Point. The question took on a different aspect when I found a *Chorizocarpa*, corresponding in general to the description of *Synstyela monocarpa*, Sluit., at Luderitzbucht in South-west Africa. We, Hartmeyer and I, then had to change our view. We must assume that there had occurred an exchange of the material, that the *Diandrocarpa* came from Thursday Island, and the *Chorizocarpa* from Sea Point. But this view also appears now to be incorrect, for in the present material from the Still Bay, on the southern coast of the Cape Province, I recognised some specimens doubtless belonging to *Diandrocarpa bråkenhielmi*, Michaelsen (1904, p. 50) (=*Symplegma viride*, Herdm.). Thus both genera are represented in the fauna of the Cape Province, and doubtless Sluiter's material from Sea Point must be regarded as a mixture of two species, of a *Symplegma* and a *Chorizocarpa*. If, therefore, the question is cleared up as far as the Cape fauna is concerned, how does this affect the Polyzoine from Thursday Island? Did that *Chorizocarpa* really come from this Island? And, if so, may we assume that *Ch. monocarpa* (Sluit.) occurs in two localities so far distant from one another? Or is the *Chorizocarpa* attributed to Thursday Island a species different from *Ch. monocarpa*, and should be called *Ch. michaelseni* (Sluit.)? According to Sluiter (1900, p. 110), it differs from his *Diandrocarpa* (*Chorizocarpa*) *monocarpa* by having papillae on the branchial sac at the points of intersection of the longitudinal and the transverse vessels. In the specimen sent to me by Sluiter, and supposed to have come from Thursday Island, there are no such papillae. I am not able to answer this question. The specimen in my possession has no fully developed sexual organs, and as for Sluiter's sketch of the sexual organs (in Michaelsen, 1900, text-fig. on p. 24, noted as from *Gynandrocarpa michaelseni*), it is doubtful whether this belongs to the *Chorizocarpa* from Thursday Island or to an intermixed specimen of *Symplegma viride*. Only by new and better material from North Australia can these questions be cleared up.

The second mistake about the synonymy of Cape Polyzoines lies in Hartmeyer's determination of *Distomus elegans* (Q. and G.) (Hartmeyer, 1912, p. 266). Since he, like myself, at that time assumed that there was only one species in South Africa in question, namely, the *Chorizocarpa*, he identified the latter with Quoy and Gaimard's species. This was erroneous. As we have now recognised a *Diandrocarpa* (*Symplegma*) from the southern coast of Africa, we must compare this species also with *Distomus elegans*. I can state confidently that this old species is identical with *Diandrocarpa bråkenhielmi*, Mich. = *Symplegma viride*, Herdm., and not with a *Chorizocarpa*. The most remarkable point in the figure and in the description of *Distomus elegans* is the fact that the branchial and atrial orifices are regularly six-rayed. We know of no Styelid with such orifices, in general they are rectangular or cross-shaped in this family; but rounded or transversely elliptical in the compound forms, formerly separated off as Polyzoines. In *D. elegans* also the orifices are only apparently and not really six-rayed. This condition, impossible in a Styelid, is only an illusion caused by a very curious pigmentation. In the species of *Symplegma* now recognised from South Africa there sometimes occurs this six-rayed arrangement of pigment in the vicinity of the actually circular or transversely oval orifices. I gave a detailed account of it and of its more or less complete state in the discussion about the Western Australian specimens of *Symplegma viride* (1928, p. 359). Quoy and Gaimard's figure of *Distomus elegans* shows the characteristic design at its fullest development. Even the dark rim at the margin of the basis of the zooid is visible in that figure. The present specimens from Still Bay show, in part, a beginning of this design, restricted in them to a comma-shaped transverse stripe at each side of the branchial orifice. (The development of the design is very different in the zooids of one and the same colony, but neighbouring zooids are more or less alike.) It may be stated, however, that the apparently lobed structure of the orifices, as seen in fig. 13 of the French authors, is surely due to the imagination of the artist, as also is the intensity of the colouring, which is doubtless exaggerated, a state of affairs often found in the pleasing pictures of old works.

Certain other characters of Quoy and Gaimard's species may be noted. In colouring it agrees remarkably well with the notes given by the collector of the Still Bay specimens. The latter are noted as "transparent, zooids bright crimson-scarlet, or vivid orange-yellow, or bright opaque-yellow." The last colour variety especially, corresponds exactly with the coloration of the figure named *Distomus elegans*, if the exaggeration of the violet colour of the mantle-tissue be reduced to a normal milky-blue.

Also the shape and the consistence of the original colony of *D. elegans* agree with those of some specimens of *Symplegma viride*, especially with

the type-specimen of the latter, with its pear-shaped, fleshy cormidia, whilst *Chorizocarpa*, as far as we know, always is encrusting. In spite of the fact that it does not occur in the present collection, I add to the foregoing Polyzoine species the other South African Polyzoine with whose synonymy it was so badly mixed, namely:

Chorizocarpa monocarpa (Sluit.).

?1895. *Synstyela incrustans* (non Herdman), Sluiter, 1895, p. 183 (?*Chorizocarpa michaelseni* (Sluit.)).
1898. *Synstyela monocarpa* (partim ?)—(perhaps to a slight extent mixed with notes about *Symplegma elegans* (Q. and G.), Sluiter, 1898, p. 55, Pl. I, fig. 12, Pl. VII, figs. 5–8).
?1900. *Synstyela michaelseni* (partim) Sluiter, 1900, p. 110.
?1900. *Gynandrocarpa michaelseni* (partim ?), Michaelsen, 1900, p. 21.
??1900. [*Synstyela michaelseni*] Sluiter, in Michaelsen, 1900, text-fig. on p. 21.
1904. *Chorizocarpa michaelseni*, Michaelsen, 1904, p. 108, Pl. II, fig. 27, 28 (Synon. only partim!).
1909. *Chorizocarpa elegans* (erron., non. Q. and G.), Hartmeyer, 1912, p. 226.
1915. *Chorizocarpa elegans* (erron., non. Q. and G.), Michaelsen, p. 413, Pl. XVIII, fig. 37.

Styela stephensoni, n. sp.

(Figs. 4–7.)

?*Styela hupferi*, Mich., var. *pygmaea*, Michaelsen, partim (specimen from Kinsembo, not the types from Ambrizette), 1915, p. 385 (not fig. 4 of Pl. XVI, nor fig. 24 of Pl. XVIII).

Localities.—Still Bay, under stones, 18/1/1932 (12 specimens): False Bay, Seaforth, on the stalk of a colony of *Distaplia capensis*, n. sp., 11/6/1932 (1 specimen).

Description: Shape and Mode of Attachment.—The animals are broadly oval or globular, attached to stones or other objects (for instance, to another Ascidia, or to calcareous Bryozoa) by a moderate stretch of the ventral side of the body, and not by means of a stalk. Sometimes the margin of the basal fixture is drawn out on one side into a rather narrow flange.

Dimensions.—The largest globular specimen (that from Seaforth) has a diameter of 7½ mm., the largest oval specimen is 6 mm. long with a width and thickness of about 4½ mm. *Styela stephensoni* then belongs to the pygmies among the simple Ascidians, like some of the allied species from Western Africa, namely *St. hupferi*, Mich. (1915, p. 379), *St. pygmaea*, Mich. (1915, p. 385, here described as a variety of *St. hupferi*, now separated from it as a full species), and *St. aequatorialis*, Mich. (1915, p. 389).

Colour of the living animals from Still Bay, according to the collector, "reddish brown": of the animals preserved in formalin, yellowish brown, sometimes with a reddish tinge, especially in the region of the apertures: best seen in the specimen from Seaforth.

Surface of the body rendered rugged by rather large, but only moderately high warts, which are smooth and rounded, and long transverse furrows, the latter especially in the ventral half of the animal.

Branchial and atrial apertures rather near one another in the mid-dorsal line of the body, the distance between them about $\frac{1}{12}$ of the whole outline of the body. In the oval specimens the branchial aperture approaches the anterior pole of the animal, the atrial aperture lies in the centre of the mid-dorsal line. They are quite inconspicuous and not prominent, since there are no external siphons. Very rarely they are marked by four cushions arranged in a cross-like manner, only once seen at a branchial aperture. As the apertures are quadrangular or transversely rhombic in the soft inner body when isolated, it is to be supposed that they are cross-shaped in the mantle.

Mantle, in general, moderately thick: in the region of attachment of the animal somewhat thinner. It is very tough, leathery, flexible: on the smooth inner surface usually grey with a slight glitter, like mother-of-pearl. In the region of the apertures the mantle shows on its inner side a reddish pigmentation.

The mantle-investment of the siphons is armed with minute, densely and irregularly crowded *internal spines*, which resemble those of *St. marquesana*, Mich. (1918, p. 29). They have the shape of a half-tube, about 0·022 mm. long and 0·009 mm. wide. Their anterior opening is almost semi-circular, furnished with a prominent spine at each side.

The soft inner body, in the preserved animal, is fixed to the mantle only at the two apertures, and here only loosely; it is elsewhere quite free. It is regularly globular or broadly oval, and has no internal siphons. When the apertures seem to be placed at the end of small wart-like prominences, this may be the result of tearing, in loosening the soft body, attached to the mantle at the apertures. The apertures of the soft inner body are four-sided.

The body-wall is delicate, with a fine but dense musculature radiating from the apertures. It bears on the inner side several rather large endocarps of about 0·4 mm. diameter, which have narrow, very short stalks when they are not sessile. There are no endocarps in the intestinal loop.

The atrial aperture is surrounded by a rather broad, circular atrial velum, which bears a great number of thread-like atrial tentacles, about 0·01 mm. in diameter, and of almost equal length.

The branchial tentacles are slender, the larger ones finger-shaped, the smaller thread-like; they are apparently regularly arranged, according to the scheme 1, 4, 3, 4, 2, 4, 3, 4, 1. Those of the fourth order are very small. The number of the branchial tentacles, calculated from a counting of a section of them, may be 48 in the specimen examined.

The dorsal tubercle (fig. 7) is a rounded rectangular cushion in the anterior part, being continued behind into a narrower posterior part, bent over to the left side. The opening of the tubercle is a longitudinal, irregularly crescent-shaped aperture, convex on the right side, irregularly concave on the left side, adjusted as a whole to the curvature of the tubercle. Internally this aperture is continued into a narrow longitudinal slit, limited to the rectangular anterior portion of the cushion.

The branchial sac is almost, but not quite, symmetrical. It bears at each side four longitudinal folds, but these are not equally high and do not, all of them, reach the hinder end of the sac. The first pair of folds (beside the dorsal lamina) are the highest, and are curled over; the third pair of

folds are only a little smaller, and are also curled over a little. Sometimes these latter folds are very much smaller. The second pair of folds are very much smaller than the first pair, and even than the third pair, but smallest of all are the folds of the fourth pair (beside the endostyle). The fourth fold of the left side does not reach to the hinder end of the branchial sac. In the middle of the latter it slopes down and soon disappears altogether. The number and arrangement of the inner longitudinal vessels could be recognised, unfortunately, only in transverse sections of the branchial sac, as the latter in all the specimens examined was much crumpled. So far as I could see, there were 8 to 10 inner longitudinal vessels to the large folds of the first pair; in the other folds the numbers must be smaller. The number of inner longitudinal vessels on the intermediate spaces between the folds is very small, restricted to two or even one. The breadth of the space between the endostyle and the fourth fold of the left side is remarkable, nevertheless it bore only one inner longitudinal vessel. The total number of inner longitudinal vessels is thus remarkably small.

The transverse vessels are of different diameters alternately, or perhaps conforming to the scheme 1, 3, 3, 3, 2, 3, 3, 3, 1. Very fine transverse parastigmatic vessels are regularly interposed between them. There are 4 or 5 stigmata in the broadest meshes of the intervals between the folds.

The dorsal lamina is moderately broad, smooth, and smooth-edged, its margin bent over to the right side.

The alimentary tract (figs. 5 and 6) is principally characterised by the great length and the shape of the stomach, and forms a double loop to the left of the branchial sac. The three limbs of this loop are parallel to the axis of the branchial sac, but are not placed in one and the same plane. The oesophagus, arising near the hinder end of the branchial sac, is moderately long, thin, and irregular. Bending in a regular curve, it forms the beginning of the first limb of the double loop of the alimentary canal, running direct from behind forwards. The stomach occupies the greatest part of this first limb of the double loop. It is long, nearly cylindrical, about 3 to $3\frac{1}{2}$ times as long as wide (3·5: 1·0–1·2 mm.), regularly rounded at both ends, sharply marked off from the neighbouring parts of the alimentary canal, and especially sharply from the narrow oesophagus. The hinder end of the oesophagus is introverted into the anterior end of the stomach, forming a small cardiac prominence, but no pyloric prominence is formed. The stomach is quite smooth externally, but its wall forms many rather broad, sharp-edged internal longitudinal folds, which reach far into the lumen (fig. 6). The number of these folds is somewhat variable, varying between 15 and 19. A fold just to one side of the longitudinal suture of the stomach is shortened in the specimen closely examined, reaching from the cardia only to the middle of the stomach. The fold lying directly to the right of the suture is bent back at the pylorus. It thereby forms a little terminal oval, lying between the fold proper and the suture. The longitudinal suture of the stomach (fig. 6) has a very remarkable shape. It is formed by a flat-topped ridge with a rather broad flat crown and more or less high sharply edged, almost vertical sides, and extends through the whole length of the stomach. The maximum height of this ridge equals the width of the folds. On the crown, not in its middle line, but nearer to one of its sharp edges, runs a narrow but deep longi-

tudinal slit, a conducting furrow. At the pylorus the edges of this furrow fuse together, and the lumen of the furrow extends a little further and ends in a minute caecum which is wholly embedded in the wall of the stomach, forming no external prominence. In the transverse section of a stomach the flat crown of the ridge is folded into about four narrow longitudinal folds. In a stomach cleared in glycerine these foldings seemed to have completely disappeared by stretching. With the help of a stronger higher power one saw here, instead of these foldings as seen in the object coloured by haematoxylin, a system of transverse stripes, caused by minute darker oval granules regularly arranged in transverse double rows—presumably the nuclei of epithelial cells, but the cells themselves were not recognisable in the unfavourably preserved material. The intestine, at its beginning, which forms the curvature between the first and the second loops of the alimentary canal, is only a little smaller than the stomach. It becomes smaller while forming the second loop. This loop runs for a little distance parallel to the stomach and then, before reaching the cardia, bends into the contrary direction, forming the third limb of the alimentary canal, running parallel to the two first limbs, but in another plane. This third limb of the alimentary canal is somewhat longer than the second limb, and about as long as the first limb containing the stomach. Like the stomach, the intestine has a conducting furrow, a narrow, rather deep longitudinal groove. It begins close by the pylorus with a minute caecum just like that at the end of the furrow in the stomach, and terminates a fairly long distance before the anus. It has no connection with the corresponding furrow of the stomach, its anterior end lying just opposite the posterior end of the latter. The rectum is not sharply marked off from the intestine. The anus, in the specimen closely examined, is a somewhat shortened, closed slit, with apparently unlobed but somewhat folded (8 folds?) margin.

Sexual Organs (fig. 4).—There are two hermaphrodite gonads on either side of the body, attached to the inner side of the body-wall. The median part of each gonad consists of a vermiform, almost rectilinear ovary, which is only slightly and irregularly winding, about 2 mm. long and ½ mm. wide and thick. It is externally smooth, filled with densely crowded eggs, mostly about 0·2 mm. in diameter, and at least nearly mature. It terminates ectally in a somewhat thinner, fairly long oviduct, which is bent away from the body-wall. The two ovaries of one side converge against the atrial aperture at an angle of about 45°, the ovarian orifices being placed close to one another. The male organs are only loosely connected with the female ones. They consist in the main of unusually large testicular vesicles, which are, some of them, simple, thickly and shortly bean-shaped; some of them, two- or three-lobed, with the shape of thick beans or pears. The simple vesicles are about 0·4 to 0·65 mm. across. These surround each ovary in two almost complete rows, clinging to the side of the ovary more or less closely, but in general leaving free its surface, which they cover only slightly in the marginal parts. Some of the vesicles are placed somewhat distant from the ovary, as if expelled by the others out of their own row. The number of vesicles belonging to one ovary is remarkably small; at the most I counted twenty of them. They are attached only loosely to the body-wall, and in a dissected and torn specimen many of them adhered more firmly to the branchial sac than to the body-wall.

The special ducts of the testicular vesicles are very thin. I was not able to make out their connection with each other, nor could I detect a spermduct into which they might discharge themselves.

Discussion.—*St. stephensoni* belongs to the larger group of *St. canopus* (Sav.), or *St. partita*, Stimps., as Hartmeyer called it (see Michaelsen, 1918, pp. 33–36), and is a member of the smaller group of species with an unstalked body. It is most closely allied to *St. marquesana*, Mich. (1918, p. 27, Pl., fig. 4, text-fig. 5), from Moçambique, with which it has in common especially the long stomach. It is sharply distinguished from that East African species, not only by the shape of its body, but also by the smaller number of stomachal folds, by the number and size of the endocarps, and especially by the shape of the sexual apparatus. The peculiar elongate shape of the stomach is also seen in some *Styela* species from West Africa; in *St. hupferi*, Mich. (1915, p. 379, Pl. XVI, fig. 5 *a*, text-figs. 2, 3), and in *St. pygmaea*, Mich. (=*St. hupferi*, Mich., var. *pygmaea*, Mich.), see above (1915, p. 385, Pl. XVI, fig. 4, Pl. XVIII, fig. 24). But both these West African species belong to the other smaller group of species with stalked bodies, and are further distinguished from *St. stephensoni* by the possession of an externally prominent caecum to the stomach.

In my paper of 1915 I have added to the types of *St. hupferi*, var. *pygmaea*, characterised by a very short stalk of the body, a specimen from Kinsembo. A re-examination of this specimen convinced me that it could not be denominated as stalked, and that the narrow area of fixation showed no trace of longitudinal furrows such as are characteristic of *St. pygmaea* as well as of *St. hupferi*. I presume that this specimen from Kinsembo should be joined to *St. stephensoni*. Since the dissection of the very small single specimen, unfavourably preserved, does not ensure a clearing up of its anatomy, I did not dissect it, leaving its systematic position in doubt.

Microcosmus oligophyllum, Heller, var. *wahlbergi*, Mich.

1921. *Microcosmus oligophyllum*, var. *wahlbergi*, Michaelsen, 1921, p. 2, Pl. I, figs. 8, 9.

Locality.—Still Bay, under stones, 23/1/1932.

Discussion.—The present specimens of *M. oligophyllum* must be referred to the var. *wahlbergi*, Mich., though they are actually close in one respect to the typical form of this species (Hartmeyer, 1912, p. 247, Pl. LI, figs. 1–3).

Appearance of the living animals, according to the collector, "no special colour"; of the animals preserved in formalin, somewhat different, mostly dirty yellowish grey, becoming darker at and towards the siphons. A few specimens show a very distinct wine-red tint, such as often occurs in Ascidians. Since these specimens were with the colourless ones in one and the same tube, and presumably were preserved jointly with them, we can hardly assume that the reddish colour is caused by a post-mortem colouring derived from some foreign source.

Shape and Fixation.—The present specimens are all smaller than the type-specimen from Natal, the largest ones about as large as the type-specimens of the f. *typica* from the Cape Province. This note is necessary, since in the original description I put forward the difference in the dimensions as a possible cause of many deviations from the f. *typica*. The present

specimens of var. *wahlbergi* are, in part, broadly attached to one another, but easily separated without hurting their mantles. As these joined specimens are pressed against each other, their shape, modified by mutual pressure, is very irregular and variable. In some of them the attachment-surface on their underside is remarkably lengthened.

In their provision of *external and internal spines* on the mantle-investment of the siphons, the specimens from Still Bay agree with the type-specimens from Durban, but the inner spines—about 0·06 mm. long—may be a little larger than in the specimens from Durban.

The dorsal tubercle of a specimen carefully examined closely agrees with that of the type-specimen, but the horn of the right side is somewhat longer than that of the left side, and forms an almost complete spiral winding inside the heart-shaped figure formed by the opening of the tubercle, which is very narrow at its anterior side.

The branchial sac differs a little from that of the type-specimen. The fifth pair of folds, next to the endostyle, extend on the type-specimen only a little beyond the middle of the branchial sac, whilst they reach very much further in the specimen from Still Bay, that of the left side over about $\frac{3}{4}$, that of the right side over about $\frac{5}{6}$ of the length of the branchial sac; the latter, therefore, over almost its whole length. In this point the present specimen approaches the f. *typica*, but in all the other points it is in accord with the type-specimen of the var. *wahlbergi*. As for the dimensions of the folds and the number and arrangement of the inner longitudinal vessels, the schema given for the type-specimen (1921, p. 4) might almost be adopted for the present specimen. On one side of the branchial sac the number of longitudinal vessels was even one larger (in all, 86), and their numbers on the first pair of folds were 19, 20 or 21, those of the fifth pair of folds always nine. In the f. *typica* the number of the inner longitudinal vessels of one side of the branchial sac varies between 51 and 60 (the inaccurate notes in the description, for instance "4 or 5 at one side of the fold," do not allow an exact counting of them). It is thus much smaller than the number in the var. *wahlbergi*, even if we choose the highest number resulting from the inaccurate notes in the description of the f. *typica*; and more especially, the number of the inner longitudinal vessels of the first pair of folds is relatively small in f. *typica*. Since the new specimens of var. *wahlbergi* do not differ strikingly in their dimensions from those of the f. *typica*, we dare no longer suggest the difference in dimensions as a cause of the difference in the number of the inner longitudinal vessels, as I did in the original description of the var. *wahlbergi*.

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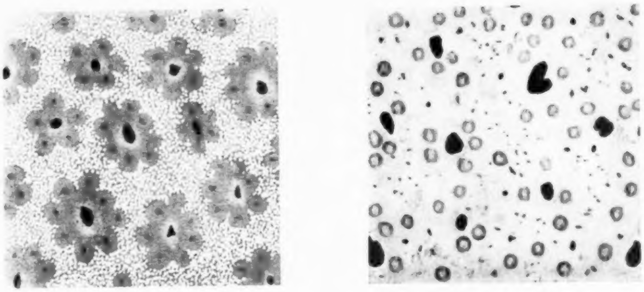
EXPLANATION OF THE PLATE.

1. *Amaroucium erythraeum*, Mich. Part of the surface of two colonies, showing the extremes of variation in the incrustation and arrangement of the zooids.
   a = specimen from St. James. b = specimen from Seaforth. 3/1.
2. *Didemnum stilensis*, n. sp. Longitudinal section through a thoracic lateral organ, filled with calcareous spicules. 600/1.
3. *Leptoclinides capensis*, n. sp. Part of the surface with a cloacal aperture. 6/1.

4–7. *Styela stephensoni*, n. sp.

4. The posterior sexual apparatus of the right side of the body. 40/1.
5. Alimentary tract, somewhat flattened into one plane. 25/1.
6. Transverse section through the stomach, opposite x; the longitudinal suture with its flattened ridge and gutter-like furrow. 35/1.
7. Dorsal tubercle. 90/1.



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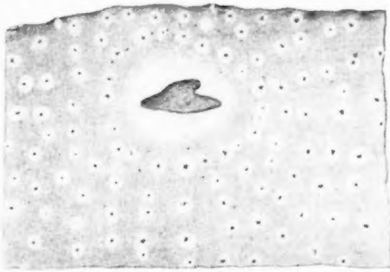

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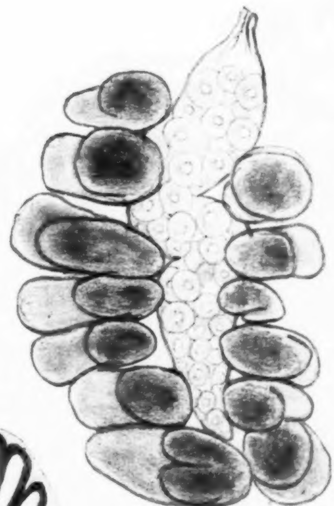

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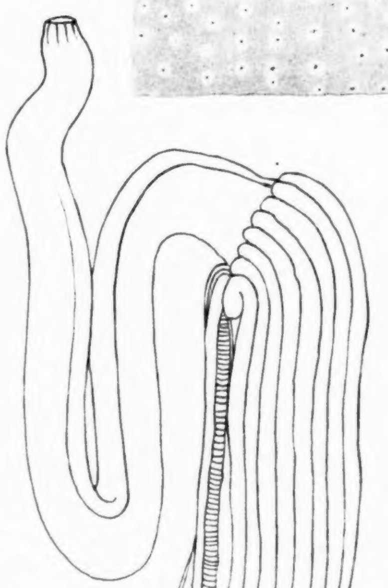

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THE STRATIFICATION OF THE SUPERFICIAL DEPOSITS AT MOSSEL BAY, AND THE AGE OF THE MOSSEL BAY AND OTHER LITHIC INDUSTRIES.

By T. F. Dreyer.

Goodwin (S. Afr. Journ. Sci., vol. xxx, 1933), in attempting to date the Mossel Bay Industry, had only very meagre information at his disposal, and thus arrived at conclusions that are now found to be incorrect. Since this area has a more complete series of post-pliocene strata than is to be found in any other South African site known to me, strata which, moreover, all carry stone implements, it is very important that all available information thereon be placed on record.

Erosion and submersion under dune-sand have rather obscured the stratification at Great Brak River, but sufficient may yet be seen to indicate clearly that it is precisely similar to that at Mossel Bay, where the following layers occur:—

Layer I.—Wind-blown surface sand on which are kitchen-middens of recent date, with pottery and with skeletons of both Bushmen and Hottentots.

Layer II.—An intensely black soil, representing a period of continuous but gentle rainfall. The middens which were formed during this period carry comparatively few stone artefacts; these are apparently of the same rough, jagged type which are found in Layer I, but pottery is absent. The writer has not found any skeletons of this period, but a skull of a young Bushman child, presented to him by the editor of the "Oudtshoorn Courant," comes from this layer at Harold's Bay—whether buried in it or contemporaneous with it is unknown. Further, the three skulls presented to him by Mr. Groenewald, Great Brak River (reference to which will be found in Dreyer, "The Bushman-Hottentot-Strandlooper Tangle," Trans. Roy. Soc. S. Afr., vol. xx, pt. i, 1931) almost certainly belong to this period, since the writer, visiting the site after the excavation, found no pottery and only coarse, jagged artefacts. These skulls are of the race called Paedogenetic by Drennan.

Layer III.—A grey, sandy layer of very variable thickness. This, apart from the superficial talus on the higher slopes of the hill which probably

belongs to the same period, is the only stratum in which the writer has found flakes belonging to the Mossel Bay Industry. Such implements are not found where the two more recent layers are intact, but are very common where the surface has been eroded down to Layer IV or V.

In the gorge just west of that in which is situated the Tunnel Cave there is an open-site kitchen-midden with the refuse embedded in a grey sand, and with a very rich store of artefacts of the Mossel Bay Industry.

The makers of this type of implement—the Matjes River Race—have been described by Dreyer (Dreyer and Lyle, New Fossil Mammals and Man from South Africa, Bloemfontein, 1930), and by Keith (Keith, "The Human Material from the Matjes River Shelter," Trans. Roy. Soc. S. Afr., vol. xxi, pt. ii, 1933).

Layer IV.—This is the red layer which Goodwin considers as synchronous with the Mossel Bay Industry. It is a hard red sand which offers very considerable resistance to erosion, but which has nevertheless been extensively eroded before the deposition of the Mossel Bay layer, since the junction between the two is sharp and distinct.

This discontinuity probably represents a long period of erosion, since upon the red layer occur implements which are of the Fauresmith type or Upper Stellenbosch.

Many exposed faces of the red layer were inspected, but no flakes of the Mossel Bay type were seen. In it, however, occur Clacton flakes and *coups-de-poing* of Stellenbosch type. Exposures in small quarry holes near the entrance to the golf course provided quite a number of these.

This layer merges into those below it.

Layer V.—This is a sandy, calcareous layer, with thin bands of almost pure lime parallel to the surface. This surface has also been eroded—its junction with the red layer is very sharp—and it is extensively cracked. The cracks, of which some are wide, likewise the pot-hole-like depressions on its surface, are filled by the red layer; or, where this has been removed by erosion, as in the Churchyard (about five feet above sea-level), by the black layer.

It would be debatable whether the sandy layer carrying lime is of one age throughout were it not for the stone implements, and for the fact that upon it always lies the hard red layer. The one exception is the Churchyard site, where there are no implements, and the black layer lies directly on it. The lime is full of shells. The omission of consideration of this site would make very little difference to the conclusions.

The only site which produced implements in this calcareous layer was the exposure made through cutting the road to the lighthouse, over two hundred feet above sea-level. Among these were well-made *coups-de-poing*, one of which was as good as the best of the Stellenbosch type; rough

(? unfinished) *coups-de-poing, still showing their origin from Clacton flakes*, and unworked Clacton flakes. Hand-axes have also been found by the writer below, in, and half-way in, the top of this calcareous layer at Mossel Bay, Klein Brak, and Groot Brak.

Layer VI.—This is a deposit which varies according to altitude. For at least forty feet above sea-level it is of the nature of a raised-beach deposit. The exposure below the Cape St. Blaize cave, which Goodwin refers to as the Twenty-foot Raised Beach, is about forty feet above sea-level. Another good exposure is to be found in the Churchyard. The writer has, like Goodwin, only found one pseudo (?) *coup-de-poing* in this deposit.

Higher up the slope of the hill (up to over 200 feet) the calcareous layer overlies a talus formation with a red matrix, quite different from the superficial talus already referred to. In this deposit a few Clacton flakes were found. In places, it overlies a thick layer of stiff red clay.

Still higher up the hill (at altitudes of from 300 to 500 feet) the calcareous layer overlies a loose sand which is either white, like a dune-sand (at the Butts), or is grey, due to the presence of numerous fine particles of a black mineral, Glauconite, probably replacing the $CaCo_3$ of the shells of Foraminifera dispersed throughout it (quarry near the Signal Post). These particles are minute, the same size as the rounded quartz particles, and perfectly rounded. No artefacts were found in this sand.

All these layers follow the contours of the much older rocks, and it may be accepted that the period represented by their deposition was preceded by a period of intense denudation over this area.

Changes of Sea-level.

A sea-level about five feet above that at present is indicated by:

I. The complete removal of the red and grey sand layers at this level, and the formation of the flat "Point Camp Site." That the black layer here lies immediately on the calcareous layer indicates that the five-foot sea-level was either contemporaneous with, or subsequent to, the period of the Mossel Bay Industry.

II. The deposition by the Great Brak River at this level of a flat terrace of a greyish sand, containing small marine shells.

III. The presence at the mouth of the Great Brak River of a beach-shelf of this height.

IV. The existence of numerous caves, the floors of which would be flooded by a five-foot rise of the sea. Such caves are without any signs of human occupation, except the one situated in the gorge already mentioned as containing an open-site Mossel Bay Industry Midden. This cave con-

tains a heap of Mossel Bay implements in a position such that it may be accepted that they are all that remains of a Mossel Bay Midden after erosion by the sea. Here the indication is that such a 4–5-foot level was attained by the sea subsequent to Mossel Bay times.

A sea-level of about twenty feet above the present is shown by:

I. The existence of a cave at this level. It is the last cave on the rocky Mossel Bay coast only about a mile east of the sandy beach, and it contains a deposit very rich in Mossel Bay implements. When the writer visited this cave nearly the whole of the deposit had been thrown out, all that remained being its margins, which had been converted into a hard stony mass by infiltration with lime.

Here we have absolute proof that the sea has not reached the twenty-foot level after Mossel Bay times. The cave possibly proves that the twenty-foot level was attained long before the time of the Mossel Bay Industry, since below the Mossel Bay deposit there is a dark-coloured deposit very rich in crushed and badly-preserved bones, which may disclose another industry.

II. The presence of rocky beach-shelves at this height. The open Mossel Bay Midden Site, already mentioned above, is on such a shelf, a conclusive proof that the level of the sea had already retreated to well below the twenty-foot level before the period of the Mossel Bay Industry. In fact, this midden tells us even more. Time and the necessary permit failing, the writer made only a small trial pit in the midden, and found that the Mossel Bay material overlies a red layer containing no Mossel Bay flakes, but one in which a single Clacton flake was found.

Further excavation of this site will thus probably show that the twenty-foot sea-level antedates even the red layer with its *coups-de-poing*, or at least the Fauresmith layer, eroded away at other sites.

The Cape St. Blaize cave must be about 100 feet above sea-level, and it seems probable that the raised-beach deposit, an exposure of which is seen below the cave at an altitude of over forty feet, is synchronous with the formation of this cave. At the time when the sea stood at this high level the Clacton-Stellenbosch technique must have been in its initial stage. It is to this far-distant period that Goodwin wishes to refer the Mossel Bay Industry.

It has been pointed out to the writer that the actual height above sea-level of a raised beach may not be the height of the same beach at another spot. In so far as raised beaches mean deposits of shells the paper makes no claim to the contrary. In fact it definitely accepts the 20-foot Raised Beach at Klein Brak (described by Rogers) as being of the same age as the 5-foot beach in the Churchyard site at Mossel Bay, and as the 40-foot Raised Beach below the lighthouse. But so far as river deposits and caves

are concerned, I cannot see that in a small area like this there can be any doubt of similar levels being synchronous.

We are now in a position to state that previous to the deposition of the six layers mentioned above, the Mossel Bay peninsula was submerged below the sea. As it emerged it was denuded of all its soft submarine deposits. That the emergence was probably continued to a level lower than the present sea-level, scouring out the dead river beds of this area. That Layer VI was deposited during this emergence. That Layers V and IV were formed during the period of greatest elevation of the land. That Layer III, carrying Mossel Bay implements, was deposited just before, or perhaps during, a 5-foot rise of sea-level. That between Layers IV and III a soft layer has been completely lost by erosion. That Layers II and I were laid down after the sea had retreated to its present level.

RESEARCHES ON THE CHLOROSIS OF DECIDUOUS FRUIT TREES.—I. PRELIMINARY.

By W. E. Isaac.

(Communicated by R. S. Adamson.)

CONTENTS.

Introduction.

Chlorosis is the term applied to that condition of a green plant in which there is an insufficiency of chlorophyll, resulting in a light green, yellow, yellowish-white, or even a white colour of the foliage, depending on the extent and nature of the deficiency. The leaf may be uniformly affected or else it may present some type of mottling. The most familiar instance of chlorosis is that which, *inter alia*, is characteristic of a plant grown in darkness (etiolation), for light is one of the necessary conditions for the formation of chlorophyll, at least in the majority of plant species. An insufficiency of chlorophyll results in an impoverishment of the plant since chlorophyll is essential to photosynthesis, and an autotrophic plant is limited to photosynthesis as a means of obtaining the carbon essential to the building up of cell structures and reserve organic compounds. It is thus important from an agricultural point of view to correct a chlorotic condition, since a diminution of effective leaf surface results in the fixation

of smaller amounts of atmospheric carbon, which in turn implies a diminished synthesis of organic substances with consequently smaller agricultural yields. Unfortunately many of the published papers dealing with chlorosis give no comparative figures of yields from normal and chlorotic plants, but still, an examination of the literature of the subject will show a number of records of stunted growth and markedly lower yields in cases of severe chlorosis. The effect of chlorosis in bringing about very reduced yields will be well seen from an examination of Table I, in which are recorded some extreme contrasts between the yields of normal green plants and plants suffering from severe chlorosis.

TABLE I.—*Comparisons of Yields from Normal and Chlorotic Plants.*

Species of plant.	Conditions under which plants were grown.	Yields. Normal crop.	Yields. Chlorotic crop.	Investigators.
Spinach (fall)	Field experiments.	1565 bushels. (fresh weight)	670 bushels.	Gilbert and McLean (1928).
Oats .	,,	1475 grams. (air-dried material)	65·0 grams.	,,
Alfalfa .	,,	220·0 grams. (air-dried material)	59·6 grams.	,,
Beets (fall)	,,	332 bushels.	89 bushels.	,,
Rice .	Water culture experiments.	393·38 grams.	6·53 grams.	Gile and Carrero (1916).
,, .	,,	51·42 grams.	6·84 grams.	,,

Important as it may be to correct a chlorotic condition in any agricultural crop, this will be particularly true of certain plants such as the Japanese varieties of plum, where at best the ratio of foliage to fruit tends to be narrow. Thus, the Kelsey plum-tree, for example, may bear a greater number of fruit than of leaves.*

In regard to origin, there are three primary groups of chloroses: (*a*) hereditary,† (*b*) pathological,‡ and (*c*) constitutional (or physiological) arising from: (i) a deficiency of some necessary substance or substances,

* In this connection it should be borne in mind that in the Western Province of South Africa a Japanese plum scion is usually grafted on a peach stock.

† For a discussion of this subject see "Recent Advances in Plant Genetics," 1932, by Sansome and Philp, pp. 54–64 (chap. i).

‡ A general account of the virus diseases of plants by Barton-Wright is given in "Recent Advances in Botany," chap. ix, 1932. See also "Recent Advances in the Study of Plant Viruses," 1933, by K. M. Smith.

(ii) the presence of some substance or substances in toxic concentrations.* On further investigation many of the chloroses now regarded as being due to toxic concentrations of some substance in the soil may prove to be deficiency chloroses, an excess of one substance resulting in deficiency of another within the plant. Most prominent among the pathogenic chloroses are those incident on the virus diseases. In these diseases chlorosis occurs in nearly every known case and is the most common symptom. We are here concerned only with the deficiency chloroses. Regarding these it should be borne in mind that in so far as the soil is concerned, the deficiency of a necessary substance may bear no relationship to the total amount present in the soil, for, in relation to the plant food substances in the soil, it is necessary to differentiate between the total amount present and the amount available to the plant. This latter in turn depends not only on the plant, the root exudations of which have a weak acid action on soil constituents,† but also on the conditions prevailing in the soil and including the hydrogen-ion concentration and the lime content. Further, due to some upset of metabolic conditions, substances absorbed from the soil may become unavailable for any particular function within the plant. A chlorosis arising as a result of an excess of one substance bringing about a deficiency in the availability of another necessary substance within the plant would be regarded by the writer as a deficiency chlorosis and not as a toxic chlorosis. The precipitation of iron within the plant resulting from an insufficiently acid sap may be taken as an example of such an indirectly caused chlorosis.

The investigation of chlorosis is a difficult one since chlorosis may arise from many causes, or at least may be induced in several different ways. The older view was that chlorosis resulted from an insufficiency of available iron, although such a condition rarely exists under ordinary circumstances. This may or may not be the case in regard to the immediate antecedent cause within the plant, but the condition may certainly be induced by a variety of environmental causes. Within recent years the need of very small amounts of certain substances (often toxic in a greater concentration) for normal growth and metabolism has become increasingly evident, although in most cases the physiology and biochemistry of the processes involved is by no means clear. In the animal organism the importance of vitamins and hormones is well known. It seems that a similar role in plants may be played by very small amounts of such elements as boron

* As an instance of what appears to be a genuine case of a chlorosis associated with a toxicity (*i.e.* a poisoning of the protoplasm) we may cite the experiments of Hoffer and Carr relating to the injection of N/100 aluminium nitrate solutions into the stalks of the corn plant (Hoffer and Carr, 1923).

† According to Dyer, equivalent to a 1 per cent. solution of citric acid.

(*e.g.* Warington, 1923, 1926; Brenchley and Warington, 1927), zinc (*e.g.* Sommer and Lipman, 1926; Sommer, 1928), and manganese (McHargue, 1922, 1926). The absence of such substances, or the presence of insufficient amounts, may cause among other things a lack of chlorophyll, resulting in chlorosis. This is best known in the case of manganese deficiency (Schreiner and Dawson, 1927; Gilbert and McLean, 1928; Lee and McHargue, 1928; Samuel and Piper, 1929; McHargue, 1922, 1923 (i), 1926). Increasing evidence is also accumulating which indicates the essential nature of copper for the healthy growth and metabolism of at least many plants (Anderssen, 1932; Smith and Thomas, 1928; McHargue, 1927). Lastly, we may call attention to the appearance of chlorosis in the Broad Bean in the absence of boron (Warington, 1923). Chlorosis may also arise due to lack of a sufficient amount of one of the mineral nutrients that have now long been regarded as essential to plant growth. This was the case with chlorotic plum trees growing in the fruit areas of the West Midlands of England, where chlorosis was found to be due to a deficiency of potassium (Wallace, 1928). A potash deficiency chlorosis has also been reported for tobacco (Garner *et alia*, 1923). Other cases of this kind are chlorosis due to lack of sufficient nitrogen (Bartholomew, 1929; Garner *et alia*, 1923), and lack of sufficient sulphur (Garner *et alia*, 1923; Mazé, 1911). It should be borne in mind at this point that magnesium is the only mineral constituent of chlorophyll, the ash of which contains 2·7 per cent. of the metal (Willstätter and Stoll, 1918). Both chlorophyll *a* and chlorophyll *b* also contain nitrogen.* The associated "carotinoids" are composed of the elements carbon, hydrogen, and oxygen only.

Lastly, in relation to the difficulties attendant on an investigation of chlorosis, it must not be forgotten that plants show varying degrees of susceptibility to the trouble. Thus Juritz (1912) found that in Floradale Farm, in the Bloemfontein area, although the pear was badly affected by chlorosis, the apricots showed no sign of the trouble. Anderssen (1932) points out, in relation to the type of chlorosis of deciduous fruit trees which he studied in the Ceres district, that "the Gaviota plum seems to be more resistant to this chlorosis than most varieties, and the Kelsey and Wickson the most susceptible. The early varieties of peaches † appear to be more susceptible than the later varieties." Also, as will be seen later, the symptoms of a particular type of deficiency chlorosis may differ in different species.

* Chlorophyll *a* = $(MgN_4C_{32}H_{30}O)CO_2CH_3CO_2C_{20}H_{39}$.
Chlorophyll *b* = $(MgN_4C_{32}H_{28}O_2)CO_2CH_3CO_2C_{20}H_{39}$.

† It is said by some observant farmers in the S.W. of the Cape Province that the peach is the most sensitive of the deciduous fruit trees to chlorosis.

Lime-induced Chloroses.

It would appear that chlorosis results very frequently, if not most generally, in cultivation due either to an excess of lime in the soil rendering other necessary elements unavailable, or to an excessive intake of lime by the plant resulting in some internal disturbance. Manganese is one of the commonest elements to become unavailable to the plant due to an excess of lime in the soil, while iron is the commonest element to become unavailable within the plant due to some disturbance of metabolic conditions. Iron generally becomes unavailable within the plant due to the absorption of excess lime. The work of McGeorge (1923), on the chlorosis of pineapple growing on manganiferous soils, would seem to show that the absorption of excess lime by the plant is not necessarily directly correlated with an excess of lime in the soil. The two groups of lime-induced chlorosis are dealt with below.

A. Chlorosis Induced by a Deficiency of Available Manganese in the Soil due to an Excess of Lime.

Schreiner and Dawson (1927) showed that in the case of tomatoes growing on a soil of a highly calcareous character (89 to 92 per cent., $CaCO_3$) and slightly alkaline in reaction, the addition of manganese as $MnSO_4H_2O$ in concentrations of 10 to 100 p.p.m. resulted in normal growth and healthy green foliage, whereas in the absence of added manganese, growth was greatly retarded and severe chlorosis and necrosis set in. Striking results were obtained on adding manganese and fertiliser, but the addition of a fertiliser alone did not prevent the appearance of chlorosis. The soil experimented with, however, had an exceedingly low manganese content, there being less than 0·001 per cent. of the element.

The work of Gilbert and McLean (1928) indicated that heavy liming may create soil conditions which induce chlorosis in many plants. Very little manganese was found necessary to correct the chlorosis of spinach and oats—a spray solution containing 8 lb. per acre of manganese sulphate was completely effective. This treatment resulted in increases of from 20 to 215 per cent. for spinach, and for oats the same treatment gave an increase of 67 per cent. (Gilbert, McLean, and Hardin, 1926).

The view that excess of lime in the soil tends to induce a chlorotic condition due to a deficiency of available manganese is regarded as receiving additional support from the investigations of McHargue on the effects of adding manganese sulphate to acid soils (McHargue, 1923 (i)). The acid soil used in the investigation was a silt loam of low organic matter content and high clay, needing 2000 lb. of calcium carbonate per acre foot to neutralise its acidity. Addition of manganese sulphate, at the rate of

10 p.p.m. of manganese, to this soil in which soybean was growing, resulted in a considerable reduction in the dry weight of the crop, while a concentration of 50 p.p.m. of manganese was decidedly toxic. On a calcareous soil, however, a concentration of 50 p.p.m. of manganese was not harmful, although it resulted in a less favourable growth as compared with lower concentrations under the same conditions. These experiments indicate that under acid conditions added manganese is more available to the plant, and in this instance with injurious effects. McHargue in his account of these experiments gives no indication of chlorosis as a symptom of injury from excess available manganese.

Piper demonstrated that normal growth can be established in soils deficient in available manganese either by increasing the acidity or by bringing about reducing (*i.e.* anaerobic) conditions in the soil. The effects brought about by these means are similar to those resulting from the application of manganese sulphate to the soil (Piper, 1931).

B. Chlorosis Induced by a Deficiency of Available Iron within the Plant as a Result of the Absorption of Excess Lime.

A case of internal disturbance resulting from an excessive intake of lime is afforded by the researches of Loehwing, who showed that grain crops grown on acid muck soils (of low potash content) were frequently injured by additions of lime, which often induced a chlorosis by making the sap too alkaline to maintain iron in solution (Loehwing, 1928). It has been shown that iron is precipitated from solution in hydrochloric acid in increasing amounts from p_H 3·5 to p_H 6·0, and at higher p_H concentrations practically no iron remains in solution (Patten and Mains, 1920). Obviously this phenomenon might be effective in the soil and within the plant. The presence of precipitated iron within the plant has been demonstrated (Loehwing, 1928; Rogers and Shive, 1932). This may account for such observations as that chlorotic leaves from fruit trees may contain as much or more iron than green leaves (Oserkowsky, 1931). Another interesting case is afforded by the work of McGeorge on chlorosis in pineapple. This investigator considered the chlorosis of pineapple leaves on plants grown in soils rich in manganese, as resulting from a greater assimilation of lime indirectly caused by the presence of manganese in the soil, although these Hawaiian soils are mostly acid with a hydrogen-ion concentration of the order of 5·9 to 6·0. The manganese content (expressed as Mn_3O_4) of three of these soils is given below: 7·3, 4·5, and 4·7 per cent. The values for the corresponding subsoils are: 3·5, 3·0, and 3·9 per cent.* These soils also have a very high content of iron (20 to 30 per

* In the manganiferous soil type, the manganese is typically present as MnO_2, as concretions or deposited as a film on the surface of the soil grains.

cent.)* and aluminium, and these together with manganese oxides are often in excess of the silica. The excess of lime in the stalks and leaves of the plant, according to McGeorge, results in the iron becoming unavailable. This view is further supported by the fact that the addition of soluble iron salts to the soil is without effect, while chlorosis of pineapple can be cured by spraying the leaves with a solution of an iron salt. This, however, has to be done periodically if young leaves are to show a normal development of chlorophyll. It should also be noted that such commercial crops as the sugar cane and especially sisal (*Agave Sisalana*) show normal growth on highly calcareous soils and yet show least disturbance when grown on manganiferous soils (McGeorge, 1923). McGeorge does not, however, put forward the view that the injurious effects of an excess of manganese are due in every case to an excessive absorption of lime by the plant. A direct toxic action may be exerted on the plant by an excess of available manganese in the soil. That this may be the case was shown by McHargue (1923 (i)).

Gile and Carrero (1916 (i) and (ii)) neatly demonstrated that iron may become unavailable within the plant. These workers found that the chlorotic leaves of plants grown on calcareous soils, or in culture solutions where the iron was unavailable, could be restored to normal colour by spraying or brushing with iron salts. The action, however, was local and there was no transference of iron salts to other leaves, and thus it was necessary to brush or spray new leaves in order to maintain the green colour of the entire plant.†

Chloroses not Associated with Excess Lime.

All cases of chlorosis occurring in the field are not, however, "lime-induced." An instance of this is seen in the chlorosis of plum trees in the West Midlands of England (Wallace, 1928). The soils (and subsoils) from the nine centres studied had, for the most part, a low calcium carbonate content, and in certain cases the soils were devoid of lime and definitely

* As Fe_2O_3.

† A somewhat similar local action has been observed in the case of copper salts applied to chlorotic plants (Anderssen, 1932; Smith and Thomas, 1928). Anderssen showed that if a chlorotic leaf of Kelsey Plum was kept immersed in a solution of copper sulphate, containing 0·3 p.p.m. of copper, for two weeks, the chlorotic condition was completely cured and the leaf assumed a normal healthy green colour. The other leaves on the same twig, however, remained chlorotic although occasionally the whole twig became green. Smith and Thomas sprinkled 2 lbs. of copper sulphate in a half-trench about a six-year-old badly chlorotic apple tree. The half-trench, which was a foot deep, was then filled with water. This was done on 23rd June and by 17th August the half of the tree which had been treated with copper sulphate showed a considerable improvement, while the other half of the tree was in a rather worse condition than before. Such a localised mode of reaction would be inconceivable for the higher animal organism.

acid. In two cases the amount of lime was as high as in some cases of lime-induced chlorosis. The character of the ash was, however, different in chlorotic leaves due to potassium deficiency as compared to chlorotic leaves due to excess of lime. Anderssen (1932) has recorded chlorosis of deciduous fruit trees in the Ceres district on acid soils. In these cases chlorosis was cured by applications of copper as copper sulphate. A magnesium deficiency resulting in chlorosis has been recorded for corn grown on acid soil in Massachusetts (Jones, 1929). We have already drawn attention to the work of McGeorge, who recorded a case of chlorosis on acid soil, the cause of which appeared to be an excess of lime within the plant, but presumably this was brought about as a result of an excess of manganese in the soil. Still, if the results of McGeorge are valid, the chlorosis which he investigated has to be regarded as lime-induced. Other valuable published accounts unfortunately contain no statements as to the hydrogen-ion concentration and lime status of the soils dealt with (*e.g.* Garner *et alia*, 1923).

The Leaf Symptoms of Deficiency Chloroses.

A study of the literature suggests that it may be possible to deduce the deficiency which has resulted in a particular chlorosis from a study of the appearance of the leaf together with a study of the sequence of changes in the appearance of the leaf from the inception of chlorosis to its full development. In regard to the appearance of a chlorotic leaf it is important to observe the pattern (if any) resulting from the presence of green and chlorotic areas, or areas of more intense and less intense chlorosis: and also the presence or absence of areas of dead tissue in the lamina. It is also important to notice whether the upper or lower leaves are more particularly affected. These characters when worked out might make it possible to determine the nature of a deficiency by an examination of the foliage. Such a mode of identification would be quicker and simpler than ash analyses. In any case, a knowledge of the symptoms of deficiency chloroses might at least aid in determining the causes of the trouble. This will involve considerable investigation, for it seems clear from the available descriptions that the same deficiency may induce different symptoms in different plants as is well seen in the case of magnesium deficiency to be dealt with shortly. It is not at all unlikely, however, that a given deficiency may result in the same symptoms for a group of related plants. Thus cereals may show the same manganese deficiency symptoms, and stone fruits the same symptoms for potash deficiency. Unfortunately, many of the papers dealing with deficiency chloroses either have no description of the character of the chlorosis involved, or give only inadequate descriptions. Where possible, the ideal practice would be to publish descriptions and

coloured plates, as was done for magnesium deficiency chlorosis of tobacco by Garner and his co-workers (Garner *et alia*, 1923).

A. Leaf Symptoms of Magnesium Deficiency Chlorosis.

Orange trees grown in sand cultures and supplied with a magnesium free nutrient solution become chlorotic. The chlorosis starts as a narrow strip of affected tissue along the midrib of the leaf and later the chlorotic zone spreads outwards until a considerable area of leaf is affected (Reed and Haas, 1924). In the case of tobacco, the chlorosis affects the lowermost leaves first. The trouble begins at the tip of the leaf and then spreads to the margins, thence advancing towards the base and central area of the leaf. The veins and immediately adjoining tissues remain green long after the rest of the leaf has become chlorotic. The chlorotic regions become a dull and very pale yellow colour, and where chlorosis is very intense, almost pure white. This chlorosis of the tobacco almost invariably shows itself only in older plants of considerable size, and so the affected leaves are normal in shape and colour. This type of chlorosis (in contradistinction to "potash starvation" chlorosis of tobacco) is not characterised by the appearance of areas of dead tissue on the leaf (Garner *et alia*, 1923). The magnesium deficiency chlorosis of corn (Jones, 1929) is in many respects the same as that of tobacco if allowance is made for the difference in the morphology of the leaves. In all but the severest chloroses the longitudinal alternation of green veins and chlorotic intervascular tissue results in a leaf of striped pattern. In severer cases the leaf becomes more uniformly chlorotic, but necrosis also sets in. As in the case of the tobacco plant, the lowermost leaves are those which are most severely affected. In the case of corn, however, the chlorosis begins to appear about two weeks after the plant has reached the surface of the ground, whereas in tobacco the trouble appears almost invariably only in the older plants. In both cases, the tips and margins are the most severely affected. The symptoms for corn, however, present a marked contrast to those recorded for tobacco in that necrosis of the tissue sets in before the complete disappearance of the green colour. "In extreme cases both the vascular and the intervascular tissues, particularly those near the border and tip of the leaf, lost their green colour, turned yellowish-brown, and dried up prematurely."

B. Leaf Symptoms of Potash Deficiency Chlorosis.

In many respects, the chlorosis of tobacco resulting from "potash starvation" is similar to that due to magnesium deficiency. The trouble affects the lower leaves first and starts at the tips and margins. The surface of the leaf, however, becomes puckered and uneven due to a difference

in the rate of growth of the vascular and intervascular tissues. Further, the chlorosis is quickly followed by the appearance, within the chlorotic areas, of small spots of dead tissue which later increase in size so that large areas of the leaf die, especially along the margins, which, as a consequence, frequently become ragged and torn. In the areas of chlorotic leaf tissue the green colour gives way to a dull yellow with a bronze or copper overcast. Lastly the margin, and especially the tip, curve downwards due to an arrested growth of the periphery of the leaf. These differences make it possible to distinguish the two types of deficiencies from one another, in typical cases, by the leaf characters, although in the earlier stages of the chlorosis this might not be possible (Garner *et alia*, 1923). The potash deficiency chlorosis of plums (Purple Pershore especially), growing in the West Midlands of England, shows essentially the same features as that described above for tobacco (Wallace, 1928). Wallace, however, makes a more specific statement to the effect that the chlorotic condition spreads inwards from the margins of the leaf between the veins and towards the mid-rib. No mention is made of necrosis of the leaf tissues.

C. The Symptoms of Manganese Deficiency.

The manganese deficiency chlorosis of tomato described by Schreiner and Dawson (1927) resembles more especially the magnesium deficiency of corn described by Jones (1929) and perhaps to a lesser extent the potash deficiency chlorosis of plums described by Wallace (1928). The chlorosis starts as a lightening of the green colour of the leaf. Later, the leaf areas farthest from the major veins become yellow in colour, which, at a still later phase become more marked and extensive, the veins still remaining green. Eventually the foliage becomes uniformly yellow, and in many cases a necrosis of the tissues sets in, appearing at first as tiny pin-point spots of brown in the yellow areas farthest from the veins, and expanding to form larger dead areas. Information on several important points, however, is lacking. There is no statement as to whether the trouble is uniformly diffused among the leaves or whether it affects either the upper or lower leaves more particularly. Again, there is no statement as to whether the leaf tips and margins are more severely affected than the other parts of the lamina. The account given implies that necrosis sets in at a late phase, and then not always.

The symptoms of Pahala * blight are essentially the same as those described by Schreiner and Dawson for manganese deficiency of tomatoes. Lee and McHargue (1928) have now shown that Pahala blight is a manganese

* A small town situated towards the southern extremity of Hawaii. The "disease" was first observed in this locality in 1906. No record of this affection of the sugar cane outside the Hawaiian Islands (Lee and McHargue, 1928).

deficiency disease, although frequently in cases of intense chlorosis *Mycosphaerella striatiformans* may infect necrotic areas on the leaf, and at one time was thought to be the cause of the "blight." The affected leaves show a streaked pattern of alternate white and green longitudinal zones, as in the magnesium chlorosis of corn. Usually the third, fourth, and fifth leaves from the youngest unfolded leaf show the symptoms most clearly. Later, small reddish spots appear in the chlorotic zones due to necrosis of the tissue. Reddish-brown streaks may arise in very severe cases from the fusion of numerous red spots, and the leaves may still later split along these streaks. Oats grown in culture solution free from manganese showed a similar behaviour to the sugar cane in that the first formed leaf was never affected, but the leaves from the second downwards showed the manganese deficiency symptoms which, however, in the case of oats do not include chlorosis (Samuel and Piper, 1929).

A good deal of work has been done during recent years bearing on the effects of manganese deficiency on the growth and metabolism of plants. Taken as a whole this work (especially that of McHargue) indicates quite clearly that the younger parts of the plant are most severely affected, and in most cases the trouble seems to set in with the very youngest leaves. This, however, is not always the case (Lee and McHargue, 1928; Samuel and Piper for oats and tomatoes, 1929). Generally the trouble seems to be much more than a chlorosis, for in the total absence of the element growth ceases, since usually the stem apex and the very youngest leaves are severely affected while the lower leaves remain green and healthy. It would also seem that a deficiency of manganese may have a detrimental effect on a plant without producing a chlorosis (McHargue for corn, 1923 (i); Samuel and Piper for oats, 1929). The young leaves as they emerge are frequently already chlorotic (McHargue, 1923 (i) and 1926), and later necrosis sets in. On the other hand, the trouble may not begin to appear until the plant is already well grown. Thus Samuel and Piper (1929) showed that peas, beans, clover, and oats flourished for a period of four to eight weeks (depending on the species) before the apical parts showed signs of manganese deficiency. In the case of grasses the effects of the deficiency appeared very early. Tomatoes behaved differently to the other plants investigated, for although the plants were very dwarfed and almost ceased to grow after attaining a height of four inches, yet the growing point did not die. The chlorosis of the tomato leaf recorded by Samuel and Piper was similar in character to the leaf symptoms of manganese deficiency described by Schreiner and Dawson. The usual reason given for the delay in the appearance of the deficiency symptoms which is shown by many plants when grown under conditions of manganese deficiency is that manganese, which is widely distributed in plants (McHargue, 1925), is generally

contained in the seeds of these species in sufficient amounts to enable the young plant to establish itself (McHargue, 1914, 1923 (ii)). In this connection we may also draw attention to the fact that different plants may need very different amounts of manganese for healthy growth. As Samuel and Piper point out: "Soils which do not appear to have sufficient available manganese for the growth of oats . . . nevertheless support an apparently normal growth of pasture plants and weeds."

D. Leaf Symptoms of Nitrogen and Sulphur Deficiencies.

Before leaving the subject of the "morphology" of deficiency chloroses, attention may be called to the type characterised by a general yellowing of the foliage. This may be caused by a deficiency of nitrogen or of sulphur (*e.g.* Garner *et alia*, 1923).

Previous Work on Chlorosis in South Africa.

From time to time, serious outbreaks of chlorosis occur among the fruit trees of the Western Province. A serious outbreak in the orchards near Bloemfontein was recorded in 1911–1912 by Juritz (Juritz, 1912), who carried out some investigations at the time. The chlorosis affected pear, peach, apple, quince, and apricot: the pear being most badly affected while the apricot showed very little chlorosis. The conclusions arising out of the investigations of Juritz were, however, indefinite, although he concluded that lack of iron in the soil was not to be regarded as the cause of chlorosis. Soils bearing chlorotic trees and soils bearing trees free from chlorosis were both well supplied with plant-food materials, but the soils from chlorotic orchards contained decidedly larger plant-food reserves than the soils from orchards where the trees showed little or no chlorosis. The investigations of Juritz, however, did not take into consideration elements such as manganese, boron, and zinc, which have in more recent years come to be regarded as necessary in small amounts for the healthy growth of at least many green plants. This is not surprising in view of the fact that Mazé, the first worker in this field, was only beginning to publish the results of his investigations about this time.

Marloth (1924, 1925) investigated the chlorosis of apricot and plum in the Wellington district. It was soon recognised that two kinds of chlorosis could be distinguished. One type of chlorosis, shown by trees growing on alluvial soils in the valley, was correlated with the presence of black alkali (sodium carbonate) in the soil. No definite conclusion was reached in regard to the cause of the other kind of chlorosis, found in trees growing on the hillside. It would seem, however, that several factors were involved, including the shallowness and poverty of the soil and the absence of humus together with the presence of white alkali (sodium chloride).

We may also mention that the latter group of soils were acid and poor in lime. The chlorotic condition of the hillside trees was frequently found to be associated with a more or less general gummosis of the roots, but to what extent this association may be significant is uncertain. In relation to the chlorosis of the valley soils we may draw attention to the fact that Juritz (1912) recorded injury of apricot trees due to brack at Onze Rust, near George, but in this case the trouble was not accompanied by chlorosis.

A more satisfactory investigation of a particular case of chlorosis was conducted by Anderssen (1932) on the plum trees of the Ceres district. In regard to the character of the chlorosis Anderssen writes: "Most plums, peaches, and apricots show a very decided yellowing of the leaves, the areas between the veins being very pale green to bright yellow; in extreme cases the smaller veins also turn yellow." This chlorosis was regularly accompanied by die-back, which was preceded by a cessation of terminal growth. The soils on which the chlorotic trees grew were light sands or sandy loams with hydrogen-ion concentrations of between 5·5 and 6·5. The manganese content of the soil bearing normal trees was higher than that of soil around chlorotic trees. Applications of manganese, however, were found to be without effect on the chlorosis. These soils had a low potash content, but Anderssen adds: "The application of potassium would no doubt be advisable from a nutritional point of view, but such applications had no effect on chlorosis." The chlorotic condition of the trees was cured by applications of copper sulphate at rates of $\frac{1}{4}$ lb. to 2 lb. per tree. This was scattered on the soil and then ploughed or dug in. Copper sulphate was also injected as a solution 2 to 3 feet into the soil, using the method of McKinnon and Lilleland (1931). This brought about a quicker reaction. Chlorotic leaves cured by applications of copper sulphate showed a higher content of copper. The importance of adding copper sulphate to the soil as a solution in order to bring about a quick response will be realised from the results of Darbishire and Russell (1907). These workers showed that small amounts of copper sulphate have little or no effect on the rate of oxidation of soils within short periods of time. In connection with Anderssen's experiments we may draw attention to the fact that Davis and Doidge (1928) tried to cure the intervascular chlorosis of the orange (mottled leaf of orange) by applications, *inter alia*, of copper sulphate. None of the experiments, however, gave positive results. This "disease" of orange is not a widespread one in South Africa, although it has caused considerable trouble in California.

Of these three investigations only that of Anderssen closely concerns the main subject of this paper, *i.e.* deficiency chloroses. Juritz came to no definite conclusion in regard to his investigation and, as already pointed out, his work was done prior to the clear recognition of deficiency chloroses.

In regard to the work of Marloth, the chlorosis of the hillside trees was not fully elucidated, but seemed to be due to a combination of causes. The data given in his paper affords no basis for regarding the chlorosis as being due to a deficiency. Lastly, the chlorosis of the valley trees was shown to be due to the toxic action of black alkali (sodium carbonate) and not to any soil deficiency.

This review of one group of chloroses (deficiency chloroses) is not meant in any way to be exhaustive, for the subject has a very considerable literature. An attempt has been made, however, to deal with what seems to the writer to be some of the chief contributions and also to deal with the different aspects of the study: various deficiencies that can bring about chlorosis; the environmental conditions that might indirectly result in a deficiency either within or without the plant; the different set of symptoms, which, at least for a given species, accompany different deficiencies; and, lastly, the different reactions of different plants to the same deficiency. Throughout, the conditions obtaining in the winter rainfall region of South Africa have been borne in mind.

In conclusion I wish to thank Professor R. S. Adamson for his criticisms of the manuscript of this paper.

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RESEARCHES ON THE CHLOROSIS OF DECIDUOUS FRUIT TREES.—II. EXPERIMENTS ON CHLOROSIS OF PEACH TREES.

By W. E. Isaac.

(Communicated by R. S. Adamson.)

These experiments were conducted on Krom River Farm, Elgin, which is part of the estate of Mr. E. B. F. Molteno.

The farm is a new one, brought under cultivation in 1933. Previously the ground was covered with Rhenoster vegetation, and was cleared and ploughed in 1932, and then planted with young Peregrine peach trees (Pickstone) at the rate of 134 trees to the acre. The young peach trees were planted in top soil (0–1 foot) only, the subsoil being dug out to the level of the underlying clay, and the tree and top soil then put into the hole. The depth of rooting of the young trees was about 8 inches. Thus each tree was, as it were, planted in a pot of top soil.

The soil at Krom Farm is over Malmesbury slates, and the whole profile is very stony. The soil extends to a depth of about 10 inches to a foot, although in regard to depth there is a marked variation. The subsoil varies from about 4 to 6 inches in depth, and is of a more gravelly character than the soil, and also it is of a lighter brown colour and is more stony. Beneath the subsoil comes a layer of "pot" clay, brown and stiff, with a great many stones of large size. This clay is derived by the weathering of the underlying rock. The hydrogen-ion concentration of the soil is 6·4 and that of the subsoil 6·0. The organic matter (or humus content) of the soil is 3·35 per cent.,* calculated on a dry weight basis. The C/N ratio is 15: 1. The calcium content (as CaO) is about 0·04 per cent.

Of the 3000 young trees planted, about 500 soon began to show serious chlorosis, the chlorotic trees being mostly together. It should not, however, be imagined that all the trees found in the "chlorotic" area were affected. The chlorosis was of a characteristic type. For the most part

* This figure is obtained by multiplying the carbon as estimated by the sulphur dioxide method of Robinson (Robinson, McLean, and Williams, 1929) by 1·923, which is a combination of the factor 1·116 for correcting the carbon figure obtained by this method as compared with the figure obtained by dry combustion, with the factor 1·724 for converting the carbon of the soil into terms of soil organic matter.

the lower leaves were affected, and in most cases the midrib and major pinnate veins stood out as green tracks, the tissue in between being of a pale green, yellowish-green, or of a yellow colour of varying intensity. A careful examination of a number of chlorotic leaves indicated that the trouble tends to start at the tip of the leaf and then work backwards along the margins, and from the margins inwards between the pinnate veins arising from the midrib. In more severe cases the whole leaf becomes a very pale colour. Later, on many of the affected leaves small reddish-brown or copper coloured spots appeared on the chlorotic areas. A further phase is marked by the appearance of larger coppery coloured areas within which spots of light brown dead tissue appear, which later enlarge, and in most cases still later give rise to a variable number of larger or smaller fenestrata in the lamina. An examination of the foliage in the middle of March showed the intensely chlorotic leaves to be in a very bad condition. In most cases the tip was missing, and in addition a variable amount of the upper portion of the leaf. Also the margins were frayed and/or showed areas of dead tissue. Farther in towards the midrib there might be areas of dead tissue and/or fenestrata. In this connection it should, however, be noted that leaves which did not show severe chlorosis, or indeed very little chlorosis, might yet show fair areas of dead tissue or a frayed surface due to falling away of dead tissue. Then again, the upper leaves do not show much chlorosis, and rarely, if at all, a chlorosis of the type we have described for the lower leaves; but still, they may show fenestrata, dead or dying tips, areas of dead tissue at the margins and nearer the midrib, and a coppery coloured network of the smaller veins. The observations recorded suggest that the condition of these peach trees is due to at least two distinct causes. The leaves showed no signs of fungal infection. Three main groups of chlorotic trees were distinguished:

A.1. Trees showing very little chlorosis.

A.2. Trees showing decided chlorosis but more particularly of the lower leaves. For the most part the lower leaves of the trees put into this group showed green midribs and veins with very definite chlorosis of the chlorophyllous tissue in between.

This group was further subdivided in regard to the intensity of the condition into A.2^-, A.2, and A.2^+.

A.3. Trees suffering from very severe chlorosis, lower and upper leaves being affected and many of the leaves being almost entirely blanched.

Most of the affected trees fell into the second group. No A.1 trees were marked out either as controls or for experimentation. A few A.3 trees were included, but the work could not be conducted entirely with A.3 trees, as these were not sufficiently numerous.

Experimental.

Controls.—Eighty-eight of the marked trees scattered over the orchard were not specially treated and thus served as controls. These trees mostly belonged to the A.2 group, and thus showed typically intervascular chlorosis of the lower leaves. These controls received the same general cultural treatment as the other trees, *i.e.* ploughing and the same water supply. The control trees were marked out on 29th October 1933, and a record of their condition was made on 8th February 1934. On the latter date the untreated trees were divided into the following groups, which were also used in classifying the results obtained with the experimental trees:—

Group I. No chlorosis.
Group II. Very little chlorosis. (≡A.1.)
Group III. Slight chlorosis } Corresponding to A.2.
Group IV. Decided chlorosis } ($A.2^-$ to $A.2^+$).
Group V. Bad and very bad chlorosis. Corresponding to A.3.

Below will be found a summary of the condition of the controls on 8th February.

Group I. 2.
Group II. 7.
Group III. 20.
Group IV. 46.
Group V. 13.

It should be noted that both the Group I trees were originally $A.2^-$, *i.e.* less severely affected than the A.2 trees. Three of the Group II trees were $A.2^-$ and four were A.2, but no $A.2^+$.

The results recorded make it clear that there is a certain tendency to outgrow the chlorotic condition without any particular treatment. On the other hand, the proportion of A.3 trees increases among the untreated trees. This complicating factor brings home the necessity in such work of dealing with large numbers of trees so that results of a statistical character may be obtained.

It may be mentioned here that Reed and Haas observed that orange trees grown in sand cultures and supplied with a potassium free nutrient solution showed incipient chlorosis of young leaves, but later a normal green colour was developed (Reed and Haas, 1924).

General Scheme of Experiments.

From the description given of the condition of the chlorotic trees and of the development of the chlorosis and necrosis, three possible deficiencies suggest themselves:

(i) A deficiency of manganese;
(ii) a deficiency of potassium;
(iii) a deficiency of magnesium.

The manganese deficiency symptoms described by Schreiner and Dawson (1927) for tomato are in close agreement with the symptoms of the chlorotic peach trees growing at Krom Farm. Most investigations, however, indicate that manganese deficiency generally affects the youngest leaves and not the lower leaves. The work of Samuel and Piper (1929) also brings out the fact that the reaction of the tomato to a deficiency of manganese is rather different to that shown by the other plants investigated. Still, it should be borne in mind that the condition of the peach trees under investigation seems to be due to two distinct causes. One of these causes affects both the younger and the lower leaves, bringing about necrosis of the tissues, although chlorosis of the lower leaves may exist without a parallel affection of the upper leaves. Analyses of the manganese content (expressed as MnO) of soils * from a chlorotic area and from a non-chlorotic area showed a decided difference, as will be seen from the following results:—

	No Chlorosis.		Chlorosis (intense).
MnO . . .	0·0088 per cent.	MnO . .	0·0033 per cent.

At best these figures indicate a low manganese content,† but that of the soil around chlorotic trees is less than half of that around normal trees.

The chlorosis symptoms of the peaches under investigation differ from the chlorosis symptoms of magnesium deficiency of tobacco, as described by Garner and his co-workers (1923), in the appearance of necrosis of the chlorotic leaves, but are in agreement with the magnesium deficiency symptoms of corn described by Jones (1929). An analysis of Krom River Farm soil for magnesium (estimated as MgO) gave the following results:—

No chlorosis.	Chlorosis.
0·12 per cent. MgO.	0·17 per cent. MgO.

There is no significant difference between the magnesium content of the two soils, and the probability of the chlorosis not being due to magnesium deficiency is indicated by the fact that the soil taken from around trees showing intense chlorosis has the higher magnesium content. In this connection, however, we might point out that Anderssen found no consistent and significant differences in copper content from soil around normal and chlorotic trees. He comments on the matter as follows: "This is to be expected, when the proximity of the soils is taken into consideration, as a matter of fact it can only be a question of time before the trees in the

* Depth of soil samples, 0–10 inches.

† HCl soluble—method of Rothamstead (Russell, 1927).

normal orchard will also become chlorotic; evidence of this can already be detected in scattered trees throughout the normal orchard" (Anderssen, 1932). We may note, however, that in the case of manganese, Anderssen records a consistently lower figure for soil around chlorotic trees as compared with soil from around normal green trees. Still, applications of soluble manganese were without effect.

Lastly, we have the possibility of chlorosis being due to a potash deficiency. The potash deficiency symptoms described for tobacco (Garner *et alia*, 1923) differ from the chlorosis symptoms shown by these peach trees in the absence of the puckered surface, which results from a difference in the rate of growth of veins and intervascular tissue, and also in that the leaf margin does not curve downwards. There is, however, agreement in that the chlorosis affects the lower leaves, starts at the tip and the margins, is intervascular in character, and in that necrosis and scorching mark the more advanced stages. The symptoms are also similar to those given by Wallace (1928) as characteristic of chlorotic purple Pershore Plums growing in the West Midlands of England; the chief difference relating to the curling of the margins (in this case towards the upper surface). It may be pointed out here that experiments conducted by the writer at Krom Farm, in which potash and manganese sulphate were added to the soil, resulted in a decided improvement in most instances as compared to those trees receiving only manganese sulphate.

A number of experimental treatments were planned in connection with the study of the chlorosis of the Krom Farm peach trees. As a result of circumstances several series of experiments were not carried out during the 1933–34 season. The experimental treatments given to the trees are tabulated below:

(i) Lime only, at the rate of about 1300 lbs. per acre.
(ii) Sulphur only. About 440 lbs. per acre.
(iii) Carus manganese sulphate * only, in increasing doses of from 62 lbs. to 992 lbs. per acre.
(iv) Manganese sulphate and lime. In all cases, lime added at the rate of about 1300 lbs. per acre. Manganese sulphate at rates of 124 lbs. and 248 lbs. per acre.
(v) Manganese sulphate and sulphur. Sulphur added at the rate of 440 lbs. per acre and manganese sulphate at rates of 124 lbs. to 992 lbs. per acre.
(vi) Manganese sulphate and sodium nitrate. Manganese sulphate added at rates of from 124 lbs. to 496 lbs. per acre. The sodium nitrate added at the rate of 320 lbs. per acre.

* Carus manganese sulphate used in all the experiments as a source of manganese.

(vii) Manganese sulphate and super-phosphate. Manganese sulphate added at rates of 62 lbs. to 496 lbs. per acre. Super-phosphate added at the rate of 216 lbs. per acre.

(viii) Manganese sulphate and potash. Manganese sulphate in amounts varying from 62 lbs. to 496 lbs. per acre and potassium sulphate at the rate of 112 lbs. per acre.

(ix) Copper sulphate only, in increasing doses from 70 lbs. to 280 lbs. per acre.

(x) Copper sulphate and lime. Lime added at the rate of about 1300 lbs. per acre and copper sulphate at rates of 70 lbs. and 140 lbs. per acre.

The soil unit adopted for all the experiments was 1/3556 acre to a depth of one foot. $3\cdot5 \times 3\cdot5$ feet, or an area of 12·26 square feet, was regarded as an adequate area for soil treatment per tree in respect of the area of the root system and the area of the pocket of top soil. Since there are 134 trees to the acre, it will be seen that there is a considerable distance between the trees, each tree having a potential area of 36 square yards.

(i) *Experiments with Lime.*—Lime added at rate of 6 ounces per tree, or about 1300 lbs. per acre. See Table I below.

TABLE I.

Experiments with Lime.

Condition of tree on 31st October 1933; before treatment.	Condition of tree on 7th February 1934; after treatment.	
A.2$^{(-)}$	Group V	Condition bad. Affection diffuse. Chlorosis and some necrosis of lower leaves.
A.2	Group IV	Chlorosis and some parallel necrosis. Basal leaves mostly affected, but some upper leaves also.
A.2	Group IV	Chlorosis and some parallel necrosis. General condition fairly bad.

(ii) *Experiments with Sulphur.*—Sulphur added at rate of 2 ounces per tree, or about 440 lbs. per acre. See Table II.

TABLE II.

Experiments with Sulphur.

Condition of tree on 31st October 1933; before treatment.	Condition of tree on 7th February 1934; after treatment.	
A.2+	Group III	Some chlorosis with parallel necrosis. Lower leaves almost entirely affected (but not lowermost leaves).
A.2	Group II	Very little chlorosis of lower leaves. Some parallel necrosis. Upper leaves affected to some extent.

TABLE III.

Experiments with Manganese Sulphate.

Mn added p.p.m.	No. of trees treated.	Condition of trees before treatment.	Condition of trees after treatment. Groups. I.	II.	III.	IV.	V.	Comments.
2	5	4, A.2 1, A.3	..	..	2	2	1	The group V tree was originally an A.3.
4	3	A.2	..	1	2			
6	4	A.2	..	2	..	1	1	The group V tree was originally an A.2+.
8	4	A.2	..	..	..	3	1	
16	6	4, A.2 2, A.3	..	..	..	3	3	No correlation between original A.3 condition and final group V condition.
32	5	4, A.2 1, A.3	..	..	2	2	1	The group V tree was originally an A.3.

(iii) *Experiments with Manganese Sulphate.*—Carus manganese sulphate was used, and was added to the soil in the form of solution at rates of 62 lbs., 124 lbs., 186 lbs., 248 lbs., 496 lbs., and 992 lbs. per acre. This is equivalent to 0·28 ounce, 0·56 ounce, 0·83 ounce, 1·11 ounce, 2·22 ounces, and

4·43 ounces per tree. Carus manganese sulphate was found on analysis to contain 10·3 per cent. of manganese. Thus dressings of 62 lbs., 124 lbs., 186 lbs., 248 lbs., 496 lbs., and 992 lbs. per acre are equivalent to additions of manganese at rates, to the nearest integer, of about 6 lbs., 13 lbs., 19 lbs., 25 lbs., 51 lbs., and 101 lbs. per acre. If the weight of an acre foot of soil be taken as 3,600,000 lbs., then the manganese added can be expressed in terms of parts per million. The dressings of Carus manganese sulphate added correspond to additions of manganese at rates of 2 p.p.m., 4 p.p.m., 6 p.p.m., 8 p.p.m., 16 p.p.m., and 32 p.p.m. respectively.

The results of the experiments are summarised and tabulated on Table III.

(iv) *Experiments with Manganese Sulphate and Lime.*—Lime added at the rate of 6 ounces per tree, or 1300 lbs. per acre. Manganese sulphate added at rates of 124 lbs. and 248 lbs. per acre.

The results obtained are recorded in Table IV.

TABLE IV.

Experiments with Manganese Sulphate and Lime.

Mn added p.p.m.	No. of trees treated.	Condition of trees before treatment.	Condition of trees after treatment.				
			Groups.				
			I.	II.	III.	IV.	V.
4	4	A.2	1	..	..	1	2
8	2	A.2	..	..	..	1	1

(v) *Experiments with Manganese Sulphate and Sulphur.*—Sulphur added in all cases at the rate of 440 lbs. per acre, or 2 ounces per tree. Manganese sulphate added at rates of 124 lbs. to 992 lbs. per acre.

Results given in Table V.

TABLE V.

Experiments with Manganese Sulphate and Sulphur.

Mn added p.p.m.	No. of trees treated.	Condition of trees before treatment.	Condition of trees after treatment.				
			Groups.				
			I.	II.	III.	IV.	V.
4	3	A.2	..	..	2	1	..
8	1	A.2	..	..	1	..	..
16	3	A.2	..	..	3	..	..
32	3	A.2	..	..	1	2	..

(vi) *Experiments with Manganese Sulphate and Sodium Nitrate.*—The sodium nitrate was added at the rate of 320 lbs. per acre, giving 50 lbs. per acre of nitrogen. Each tree received a dressing of 1½ ounce of sodium nitrate. Manganese sulphate was added at rates of from 124 lbs. to 496 lbs. per acre.

Results given in Table VI.

TABLE VI.

Experiments with Manganese Sulphate and Sodium Nitrate.

Mn added p.p.m.	No. of trees treated.	Condition of trees before treatment.	Condition of trees after treatment.				
			Groups.				
			I.	II.	III.	IV.	V.
4	5	A.2	1	1	..	3	..
8	6	A.2	..	..	3	3	..
16	6	A.2	..	..	..	5	1

(vii) *Experiments with Manganese Sulphate and Super-phosphate.*—Superphosphate was added at the rate of 220 lbs. per acre, or 1 ounce per tree. The super-phosphate used was equivalent to 19·1 per cent. P_2O_5. Consequently P_2O_5 was added at the rate of 42 lbs. per acre. Manganese sulphate was added at rates of 62 lbs. to 496 lbs. per acre.

The results are recorded in Table VII.

TABLE VII.

Experiments with Manganese Sulphate and Super-phosphate.

Mn added p.p.m.	No. of trees treated.	Condition of trees before treatment.	Condition of trees after treatment.				
			Groups.				
			I.	II.	III.	IV.	V.
2	3	A.2	..	1	1	1	..
4	5	A.2	..	2	1	2	..
8	2	A.2	..	..	..	2	..
16	3	A.2	..	..	..	3	..

(viii) *Experiments with Manganese Sulphate and Potash.*—Potassium sulphate added at the rate of 112 lbs. per acre, which is equivalent to about 54 lbs. of K_2O. Each tree received a dressing of half an ounce of potassium sulphate. Manganese sulphate added in amounts varying from 62 lbs. to 496 lbs. per acre.

The results are recorded in Table VIII.

TABLE VIII.

Experiments with Manganese Sulphate and Potash.

Mn added p.p.m.	No. of trees treated.	Condition of trees before treatment.	Condition of trees after treatment. Groups.					Comments.
			I.	II.	III.	IV.	V.	
2	3	A.2	..	..	..	3	..	
4	3	A.2	..	1	1	1	..	
8	2	A.2	1	1	..	..	..	Tree showing no chlorosis; very healthy.
16	2	A.2	..	2	..	..	..	

(ix) *Experiments with Copper Sulphate.*—Copper sulphate added to the soil at rates of 74 lbs., 148 lbs., and 296 lbs. per acre; or 0·33 ounce, 0·66 ounce, and 1·33 ounce per tree. The copper sulphate was applied in the

TABLE IX.

Experiments with Copper Sulphate.

Cu added p.p.m.	No. of trees treated.	Condition of trees before treatment.	Condition of trees after treatment. Groups.				
			I.	II.	III.	IV.	V.
5	4	A.2	..	1	1	2	..
10	4	A.2	..	1	2	1	..
20	4	A.2	1	3	..	..	..

form of solution. Taking the weight of an acre foot as 3,600,000 lbs., the above dressings of copper sulphate means additions of copper at rates of 5 p.p.m., 10 p.p.m., and 20 p.p.m. respectively.

The results are recorded in Table IX.

(x) *Experiments with Copper Sulphate and Lime.*—Lime added at the rate of about 1300 lbs. per acre, or about 6 ounces per tree. Copper sulphate added at rates of 74 lbs. and 148 lbs. per acre.

The results are given in Table X.

TABLE X.

Experiments with Copper Sulphate and Lime.

Cu added p.p.m.	No. of trees treated.	Condition of trees before treatment.	Condition of trees after treatment. Groups.				
			I.	II.	III.	IV.	V.
5	4	A.2	..	..	1	3	..
10	4	A.2	..	1	2	1	..

DISCUSSION.

The interpretation of the results obtained in an investigation such as that under consideration is rendered difficult for at least three reasons:

(1) As seen from an analysis of the controls, about 10 per cent. of the untreated plants tended to outgrow the chlorosis. In two cases the chlorosis disappeared completely.

(2) In conducting such field experiments, the work is necessarily carried out under conditions that cannot be carefully controlled as would be the case in a laboratory investigation using culture solution methods. In this connection it should be remembered that very small quantities of certain elements may affect the growth of plants in a beneficial or deleterious manner. The use of chemicals containing impurities has been responsible for the delay of plant physiologists in recognising the importance of certain elements such as zinc, boron, and manganese, which are necessary only in small quantities for the normal growth and metabolism of the green plant. In using products such as Carus manganese sulphate, small quantities of elements that might exert a definite physiological action may be added, as will be realised in reading the following quotation from the booklet

supplied by the Carus Chemical Company: "Besides soluble manganese, Carus manganese sulphate contains some soluble iron, zinc, magnesium, and calcium."

(3) In marking out trees, recording results, and making comparisons, it is impossible to exclude a subjective element, whereas if a quantitative mode of measurement be used the results are more definitely objective.

In addition to these general limitations, we would again call attention to the complicating fact that the condition of the sick peach trees at Krom Farm may be due to two distinct causes.

The Effect of adding Lime to Chlorotic Trees.

Previous investigations have shown that the hydrogen-ion concentration and lime content of a soil are important factors in determining the availability to the plant of certain substances in the soil. Thus manganese has been shown to become less available in the presence of an excess of calcium carbonate, and the same is true of iron. On the other hand, toxic concentrations of available aluminium, iron, or manganese can frequently be remedied by applications of lime. It would thus seem a first logical step in the study of the chlorosis of the peach at Krom Farm to test out the effects of applications of lime to chlorotic and normal trees. The object of applying lime to normal trees would be to attempt to induce chlorosis artificially. Unfortunately, circumstances prevented the experiments with normal trees being carried out in 1933, but it is hoped that they will be carried out some time in the near future. An examination of Table I will show that the addition of lime has but little effect, although it certainly does not result in an amelioration of the chlorotic condition, and in one case at least (an A.2⁻) the chlorosis became intensified. The response of the chlorotic peach trees to applications of lime would at least seem to indicate that the chlorosis is not due to:

(*a*) Aluminium toxicity, for previous work has shown that in such cases the addition of lime generally brings about an improvement of conditions (*e.g.* Hartwell and Pember, 1918; Mirasol, 1920; Hoffer and Carr, 1923; Kelly, 1923).

(*b*) Excess of iron, since increasing the lime content would reduce the concentration of available iron.

(*c*) Excess of manganese, since the availability of this element would be reduced by additions of lime.

The addition of lime in conjunction with manganese sulphate (Table IV) does not materially affect the results, although perhaps the condition of the tree is made somewhat worse.

The Effect of Sulphur Dressings on Chlorotic Trees.

A second series of experiments was designed with a view to studying the effects of increasing the acidity of the soil. This could be done by adding either sulphur, ammonium sulphate, or sulphuric acid. The addition of ammonium sulphate was immediately ruled out as this would entail the addition of nitrogen. The addition of sulphuric acid seemed a very drastic treatment, although it was used in the researches of Smith and Thomas (1928) without any apparent effect, either deleterious or beneficial.* Thus it was decided to make use of sulphur. The action of sulphur proved to be a little peculiar, for although it brought about an improvement in the intervascular chlorosis of the lower leaves, the foliage did not become a healthy green, but remained a light green colour, and the whole plant assumed a somewhat unhealthy appearance. Further, the addition of sulphur did not in any way correct the tendency to necrosis. These results accord with those obtained on adding both sulphur and manganese sulphate to chlorotic trees (Table V). It is difficult to make any precise deductions from these results. We may, however, call attention to the fact that Garner and his co-workers showed that the magnesium deficiency chlorosis of tobacco was aggravated by additions of sulphates to the soil (Garner, *et alia*, 1923). This may be regarded as further supporting the evidence already given, indicating that the chlorosis of the peach trees under investigation is not due to magnesium deficiency.

The Experiments with Copper Sulphate.

Of the remaining results by far the most significant are those obtained in the experiments in which chlorotic trees were treated with copper sulphate, for copper sulphate was found to have a very decidedly beneficial effect. An improvement in the condition of the trees was evident with applications of copper as copper sulphate in concentrations of 5 p.p.m. and 10 p.p.m., but an application of 20 p.p.m. resulted in the complete or almost complete disappearance of the chlorosis in every case (Table IX). In addition to this, the treated trees had a very healthy appearance and the leaves were of a dark green colour. In this latter respect a contrast is afforded to those experiments in which sulphur was added to the soil, for although in those cases there was a tendency for the characteristic intervascular chlorosis to disappear, the foliage had a light green, somewhat unhealthy appearance. The results of the copper sulphate experiments indicate copper deficiency as the probable cause of this chlorosis. Similar

* Three trees were selected and each treated with 500 c.c. of commercial sulphuric acid diluted with water to 5000 c.c.

positive results were obtained by Anderssen (1932) for plum, peach, and apricot trees growing on acid soils in the Ceres district. During the coming year it is intended to carry out ash analyses of the leaves with a view to seeing whether similar results will be obtained to those of Anderssen, who was able to demonstrate a difference in the copper content of normal and chlorotic leaves, and also an increase in the copper content of chlorotic leaves cured by applications of copper sulphate. The addition of lime in conjunction with a low concentration of copper had a somewhat injurious effect (Table X). Possibly the copper becomes less available with a decrease of soil acidity. Certainly the application of lime to chlorotic trees does not improve their condition. Further experiments are necessary in this direction. Attention may be called to the work of Allison, Bryan, and Hunter (1927), who showed that in the case of the highly calcareous saw-grass peat in the Everglades of Florida, such a small application of copper sulphate as 30 lbs. per acre allowed of a good growth of useful crops while normally the conditions in this soil are so unfavourable that most crop plants fail entirely soon after planting. A positive result was obtained for each of the fifty-nine species of plants tested, although copper sulphate only was used. The results obtained with copper were much more clearly marked than those obtained with either manganese, boron, chromium, arsenic, or zinc. On the other hand, Brenchley (1932) carried out experiments with fenland peat from Suffolk (p_H, 7·75), and a typical acid peat from Dartmoor (p_H of 4·57). In no case did the addition of copper sulphate bring about an improvement which might exceed experimental error. Further, barley grown on fenland peat to which copper sulphate was added, showed a chlorosis of the leaves at an early age. The leaves at first became yellowish and later streaked and spotted with brown, while the whole plant became increasingly unhealthy in appearance.

The Experiments with Manganese Sulphate.

These experiments (Table III) indicate clearly enough that in spite of the low percentage of manganese in the soil and the difference in manganese content between soil from areas showing severe chlorosis and areas where growth is normal, the chlorosis is not caused by a deficiency of manganese (*cf.* Anderssen, 1932). Applications of manganese sulphate in amounts exceeding 6 p.p.m. of manganese (*i.e.* 186 lbs. of Carus manganese sulphate per acre) would seem to exercise a decidedly toxic effect. Dressings of manganese sulphate at rates of 124 lbs. and 186 lbs. per acre seem to bring about an improvement in the condition of the trees. The general conclusion arising out of the results, however, is very evident—manganese deficiency is not the cause of the

chlorosis. Although the manganese content of the soil is low, it is probably easily available due to the acid conditions. A study of the literature reviewed by the writer in the first paper of this series (Isaac, 1934), indicates that manganese deficiency chloroses are almost invariably recorded from soils of neutral or alkaline reaction, and rich in calcium carbonate. In this connection, however, we wish to draw attention to the work of Piper (1931), who demonstrated that normal growth can be established in soils deficient in available manganese, either by increasing the acidity or by bringing about reducing (*i.e.* anaerobic) conditions in the soil (*e.g.* by water-logging). Thus it would seem that a deficiency of available manganese might arise as a result of conditions favouring rapid oxidative processes. Such conditions may prevail in either lime-rich or lime-poor soils, since they would be related more directly to climatic conditions (particularly temperature) and the physical structure of the soil in respect of aeration. It may be mentioned, however, that oxidative processes generally take place more rapidly in soils with an adequate supply of calcium carbonate. The possibility of manganese exerting a toxic action in the untreated soil of chlorotic areas is precluded (*a*) by the fact that soil taken from areas where the trees are free from chlorosis has the higher manganese content; (*b*) the addition of lime to the soil aggravates the trouble, although lime has been shown to render manganese less available; (*c*) the manganese content of the soil in a Kelsey Plum orchard at Dwaarsriviers Hoek, where the trees (grafted on to peach stocks) are in a healthy condition, is considerably higher, as shown below.

Soil (0–1 feet) . . .	0·0336 per cent. MnO,
Subsoil (1–2·5 feet) . .	0·010 per cent. MnO.

This soil has about four times as much manganese as is found in the soil from the chlorosis-free area of Krom Farm peach orchard, and about ten times as much manganese as from soil around the chlorotic peach trees. The soil at Dwaarsriviers Hoek Kelsey orchard has, however, a p_H of about 6·9, and the subsoil a p_H of 5·8. On the other hand, the addition of soluble manganese to the chlorotic soil areas at Krom Farm in amounts exceeding about six parts per million tended to increase the unhealthy condition of the trees. We cannot leave this subject without calling attention to the fact that the trees at one end of the Kelsey Plum orchard at Dwaars-riviers Hoek Farm show a chlorosis. The manganese content (as MnO) of the soil about the chlorotic trees is as follows:—

		p_H.
Soil (0–2 feet) . .	0·017 per cent. MnO	6·4,
Subsoil (2–3 feet) . .	0·0044 per cent. MnO	5·6.

It will be seen from the figures given, that the subsoil of the chlorotic areas

at the Dwaarsriviers Hoek orchard has a higher percentage of manganese than the soil around the chlorotic trees at Krom Farm. In this connection it should be mentioned that the soils from both ends of the Dwaarsriviers Hoek Kelsey orchard show marked differences in regard to the various inorganic constituents, the soil from the chlorosis-free areas being the richer in mineral nutrients. The organic constituents (carbon and nitrogen) are similar in both.

Experiments with Manganese Sulphate and Mineral Fertilisers.

A number of experiments were carried out in which either sodium nitrate, super-phosphate, or potassium sulphate were added to the soil along with manganese sulphate. These experiments represented only a part of the proposed scheme, for the experiments involving the addition of these fertilisers in various combinations with one another in conjunction with manganese sulphate were not carried out due to pressure of circumstances. The idea involved in planning these experiments was that a plant might be handicapped in its recovery from a deficiency chlorosis by the presence of an inadequate supply of some substance or substances in the soil. Schreiner and Dawson (1927) in their pot experiments on tomatoes found that in the absence of fertiliser or manganese, growth was greatly retarded, and a bad chlorosis and necrosis set in. When manganese was added without fertiliser growth was retarded for several weeks, but ultimately progressed slowly but more or less normally. The foliage was, however, healthy and green. With the addition of fertiliser alone growth was at first satisfactory, but later became retarded and chlorosis set in. Lastly, the addition of manganese and fertiliser ensured luxuriant growth from the first, chlorosis being quite absent. Marloth (1925) suggested that the general poverty of the soil was a contributory factor in the chlorosis of the hillside fruit trees of the Wellington District. Again we may note that Putterill (1921), in reporting on the chlorosis of Kelsey Plums in some Wellington orchards, suggested the cause to be the general infertility of the soil. This was only a suggestion, and although, as is most probable, there was a more specific cause for the chlorosis, the general infertility of the soil may have been a contributory factor.

Of the experiments in which a single fertiliser and manganese sulphate were added to soil about chlorotic trees, a positive result was obtained only with potassium sulphate (Table VIII). The addition of potash resulted in a very decided improvement, one tree entirely recovering from the chlorotic condition. The addition of sodium nitrate or of superphosphate had no effect on the chlorosis of the leaves; neither did it seem to have any marked effect on the toxic action of the manganese.

Conclusions.

The results of this first set of experiments on the chlorosis of peach trees growing on Krom Farm would seem to justify the following deductions:—

1. The chlorosis of the peach trees at Krom Farm can be cured by applications of copper sulphate solution to the soil in sufficient quantity so as to give the soil a dressing of about 20 p.p.m. of copper.
2. The condition of these chlorotic peach trees can be improved by applications of potash to the soil.
3. The condition of the sick peach trees suggests that at least two distinct sets of injurious circumstances are operative in the soil.
4. The peach trees are not in any way suffering from manganese deficiency.
5. The unhealthy condition of the trees is further aggravated by additions of lime, which points to the conclusion that the trees are not suffering from excess of available aluminium, iron, or manganese.
6. The soil analyses further strengthen the view that the unhealthy condition of the trees is not due to manganese present in toxic concentrations.
7. The soil analyses also indicate that the trees are not suffering from a deficiency of magnesium.

The experiments recorded in this paper are to be regarded as a first series of experiments on the chlorosis of the peach trees growing at Krom Farm. The writer is not delaying publication, since circumstances may prevent him personally from going further into the matter, and it is to be hoped that a record of the work done may be of help to other students of the causes inducing chlorosis under agricultural conditions. As has been already intimated, however, it is intended to initiate further work in this direction. The relevant part of the scheme of further work is given below:

(i) Further work on the relation of copper to the chlorosis of peach at Krom Farm, together with additional experiments on the effects of additions of lime to the soil.
(ii) The effects on the peach trees of additions of zinc and magnesium.
(iii) The effects of dressings of lime on normal peach trees growing in the same orchard.
(iv) Further experiments with potassium sulphate.

In conclusion I wish to thank Mr. E. B. F. Molteno for his kindness in giving me every facility for conducting the experiments recorded in this paper. Also I should like to thank Mr. Philp Zeitsman for his co-operation

in carrying out the experiments. For the soil analyses of manganese, magnesium, and calcium oxides quoted I wish to thank Mr. Cohen and Mr. H. Jacobs, and I wish to thank the latter also for his analysis of the manganese content of Carus manganese sulphate. Lastly, I am indebted to Professor R. S. Adamson for his criticisms of the manuscript of this paper.

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SMITHFIELD IMPLEMENTS FROM A NATAL COASTAL SITE.

By J. Gordon Cramb.

(Communicated by R. A. Dart.)

(With 4 Sketches and 5 Figures.)

(Read April 18, 1934.)

Implements which are definitely assignable to the Smithfield Culture are of frequent occurrence in archaeological sites on the Natal sea-coast. Artefacts have been collected from these sites which may be classified as:

1. Middle Palaeolithic implements of the Glen Grey type.
2. Stillbay.
3. Wilton.
4. Smithfield.

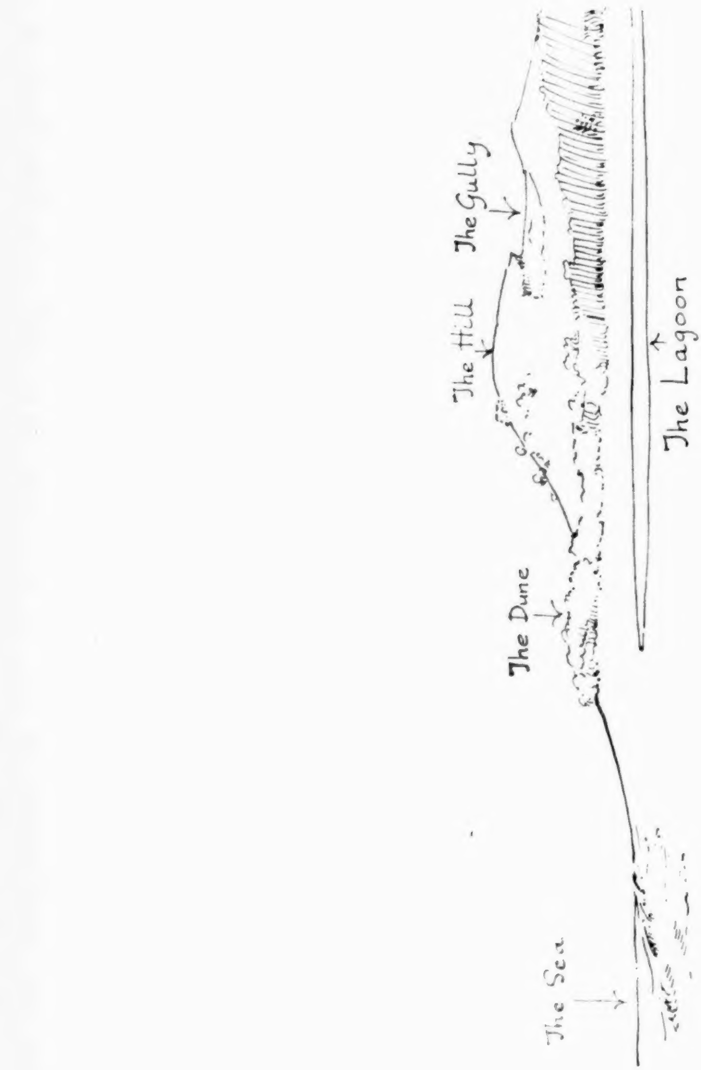
As far as I am aware, the only report previously written on Natal coastal sites is by Mr. P. G. Brien of Durban.* Mr. Brien's paper gives an excellent description of the localities of the sites and of the older types of implements from them (*i.e.* Glen Grey type and Stillbay), but gives little information of the Smithfield Culture, which is well represented at the Karridene site, which I have investigated during the past twelve months.

Description of Site.

The Karridene or Umzimbazi river flows into a large lagoon thirty miles south of Durban. The lagoon which is approached through the grounds of the Karridene Hotel is bordered on the south-west by a low-lying dune of stunted bush and sand, which runs parallel with the lagoon to the sea-shore, thence turning at right angles, and follows the coastline southwards. Behind this dune the hill on which the site is to be found rises steeply to a height of about 120 feet above sea-level. On the landward side it slopes more gradually in a north-westerly direction to the gully (see Sketch No. 1).

The gully which has been formed by wind erosion is 25 yards wide and 200 yards long and rises gradually from north-east to south-west and at its upper end merges in the hill. It is flanked on its eastern side by a steep

* S. Afr. Journ. Sci., vol. xxix, October 1932, pp. 742–750.



Sketch No. 1.

bank about 12 feet in height and towards the west by grassy hills about 10 feet high, marked (III) on Sketch No. 2.

The Smithfield section, which measures about 80 yards by 50 yards, occurs at the northern end of the gully and is marked (V) on Sketch No. 2.

To the west of the Smithfield section is an area which has been occupied by an iron-working people probably of Bantu stock; numerous fragments of slag and iron stone are lying about amongst sherds of typical Bantu pottery.

Immediately to the north of the Smithfield section is a layer of calcareous nodules in the sand, which is doubtless the remains of an old shell midden. Still farther to the north, and bordering on the belt of bush, is another more recent midden in which shells are still intact.

Stratigraphy of Site and Localities of Artefacts.

The Sketch (No. 3), depicting a cross-section of the gully, shows a series of four strata. The core of the hill (Stratum A) consists of hard red soil. Superimposed on this is a layer of yellow soil (Stratum B) which has the appearance of a consolidated sand dune. Above this layer is a covering of greyish-black earth (Stratum C), while overlying this is a final layer of surface soil (Stratum D). The floor of the gully consists of Stratum "A," while a thin layer of Stratum "B" is superimposed on this, mainly at the south-west end. Surface soil covers "C" in certain places.

Implements have been collected from the Karridene site which I have catalogued as:

1. Glen Grey type.
2. Stillbay.
3. Wilton.
4. Smithfield.

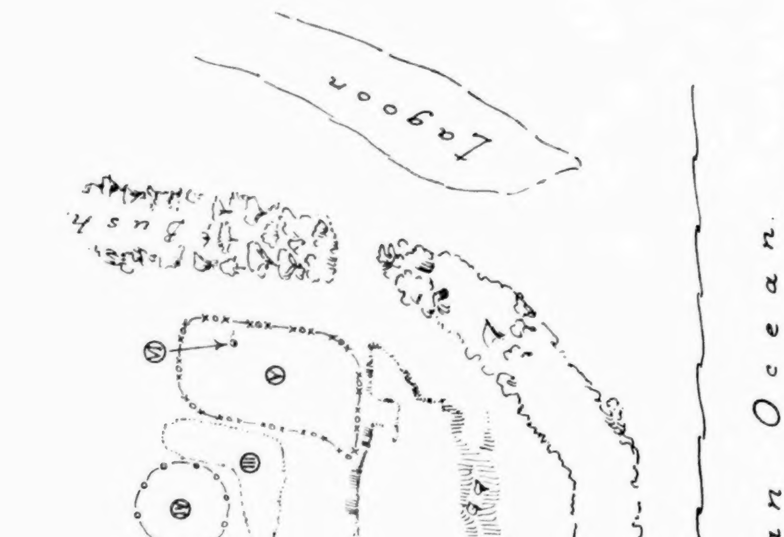
The patination, typology, and locality of the various implements have been used in their classification.

Approximately twenty Glen Grey types of implements of poor quality were collected in the gully. These implements are made of indurated shale and are deeply patinated.

Three Stillbay lance heads (points missing) were also found in the gully. Two of these implements are made of indurated shale, weathered yellow and slightly burnished, while the third is delicately worked in quartz.

I associate the Glen Grey type and Stillbay implements with Stratum "B," not only on account of the greater percentage having been found on this layer, but because these implements show no trace of discolouration or oxidization as would be the case had they been associated with Stratum "A."

Fifteen Wilton microliths were taken in various parts of the Smithfield



I. Hill. II. Gully. III. Grass hills. IV. Iron-working area. V. Smithfield section. VI. Burial.

Sketch No. 2.


KARRIDENE SITE.
Section of Gully.
Sketch No 3.
12' 0"
A
B
C
D

section. They are fashioned in Chalcedony and rock crystal and consist mainly of scrapers, no crescents having been collected.

The Smithfield section is littered with fragments of stone and has yielded approximately 150 well-worked Smithfield tools of indurated shale, which show little or no patination. The area in the vicinity of the burial (see Sketch No. 2) has proved to be the most prolific in implements.

The Wilton and Smithfield implements lie on Stratum "C," which varies from three to nine inches in depth in this section of the site.

Description of Smithfield Implements.

General.

Ninety-five per cent. of the implements are made of indurated shale, the balance mainly consisting of tools worked in quartz.

The flake technique, core technique, and a Neolithic type of technique have been used in their manufacture.

The flake technique is exceedingly poor. Secondary trimming has been used to produce a cutting edge, and prepared striking platforms are not in evidence. Few definite implements embodying this method of manufacture have been collected.

The core technique has been used in the manufacture of approximately seventy-five per cent. of the implements, fine resolved flaking generally having been used in the sharpening process.

A Neolithic-type technique is indicated by the finding of polished lance heads, a perforated chopping tool, and a polished pestle.

A large grinding stone and several small grinders were also found associated with this industry.

Unless otherwise stated, it is to be inferred that the implements described in this paper are made of indurated shale.

Summary.

From the foregoing description of typical implements from the Karridene site it is obvious that there is little or no correlation between these implements and those of the known phases of the Smithfield Culture. The absence of patination indicates the industry to be of no great antiquity; it may therefore be dated as Smithfield or even later. The Karridene industry suggests the introduction of a new variation of the Smithfield Culture, also showing this culture to have a further Neolithic facies.

Was this new variation introduced from the south coast or did it originate in the hinterland, or is it essentially a coastal or Asturian-type industry of specialised technique introduced by way of the Natal north coast?

Excavations in a cave at Umgazana, on the Pondoland coast (by E. C.

Chubb and Dr. King of Durban), revealed Smithfield implements in which the flake technique predominated. Apart from the fact that the Umgazana implements have been designated as a variation of Smithfield A, few core tools were found, which discounts the possibility of any correlation existing between this industry and that of Karridene.

Smithfield implements from Weenen in the Natal midlands * are typified by the presence of innumerable "strangled" end-scrapers. This type of scraper is also featured by Mr. J. F. Schofield in his paper "Salisbury Commonage Sites." † No implements of this type were found at Karridene, nor have they been found at any other coastal site as far as I am aware.

The presence of decomposed shell heaps on the Karridene site shows these persons to have included shell-fish in their diet. It does not seem feasible that the numerous finely-worked Asturian-type chopping tools, the perforated chopping tool, and the polished lance heads could be the work of persons from the inland savannahs, thus fashioned in order to suit new requirements resulting from a change in environment. Forty good specimens of chopping tools have been collected at Karridene. They compare favourably with the Asturian "pic" and "cleaver" types of implements described by H. Obermaier in his book Fossil Man in Spain.‡ I suggest, therefore, that the Karridene industry was introduced via the north Natal and Zululand coasts, and that the specialised techniques used in the manufacture of these implements are peculiar to a race who combined a shell-fish or Strandloper diet with their hunting activities.

I would like to point out that there can be no connection between the Karridene industry and the numerous Strandloper shell middens of the Natal and Zululand coasts. I have excavated several of these middens, and have seen the result of similar excavations (by E. C. Chubb and Dr. King of Durban), and not a single implement of any description has been found, sherds of pottery being the only artefacts revealed.

It is noteworthy that a polished lance head, somewhat smaller than those from Karridene, was found by Mr. S. Dean of Durban in a Smithfield site near Durban North.

It has been suggested to me that the perforated chopping tool described in this paper (No. 1 of fig. 4) is merely a typical Smithfield polished ringstone in the making. Two similar chopping tools have been found on this coast, one in a shell heap at Illovo Beach (1 mile from Karridene) by Mr. A. C. Coyne of Durban, and the other, which is in the Durban Museum,

* A. J. H. Goodwin, "A New Variation of the Smithfield Culture from Natal," Trans. Roy. Soc. S. Afr., vol. xix, pt. 1.

† J. F. Schofield, "Salisbury Commonage Sites," S. Afr. Journ. Sci., vol. xxix, October 1932, pp. 772–777.

‡ H. Obermaier, Fossil Man in Spain, pp. 351–353.

was found sixty feet below the road-level at Port Shepstone ; it shows poor echnique and is slightly patinated. The finding of these similar implements, combined with the fact that the Karridene tool shows signs of use on its finely resolved edge, undoubtedly eliminates the ringstone theory.

I doubt whether the broken perforated tool No. 2 of fig. 4 was intended for use as a chopper. The ochre-coloured incrustation on the upper surface of this tool is reminiscent of the polished ringstones from the Umgazana Cave, Pondoland (excavated by E. C. Chubb and Dr. King of Durban), which were coated with red ochre either for ceremonial or decorative purposes. Small lumps of red ochre have been found on the Karridene site.

Serious work yet awaits the archaeologist among the numerous sites of the Natal sea-coast. I am confident that information to be gleaned from this prehistoric highway will be of value in shedding further light on South Africa's prehistory.

Description of Burial.

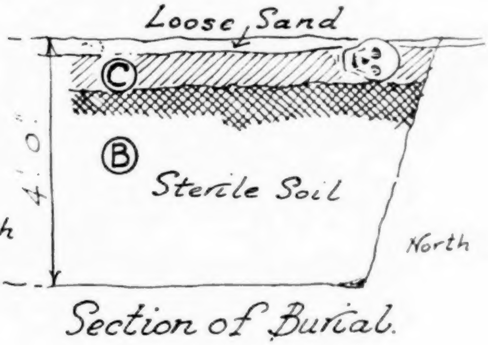
While continuing investigations at the Smithfield site I noticed a small portion of a skull protruding from Stratum "C." After three hours of careful work, the skull was excavated, completely encased and filled with this hard matrix. Other portions of the skeleton were found to be similarly buried, but it was not deemed wise nor necessary to remove them on account of their extreme brittleness and decay and the hard nature of the soil. The skull was found to be facing east; the other skeletal remains were scattered, and it was not possible, therefore, to determine if the burial had been made in a contracted position. The skull, and specimens of implements, earth, and bone were forwarded to Professor Dart for examination.

Because the skeleton was found slightly below the common level of Smithfield implements, I hoped at first to associate it with an older culture, and for this purpose sank a trial trench from the lower side of the site (near lagoon) for a distance of about five yards in the direction of the burial (see Sketch No. 4). The depth reached at the burial was 4 feet. Stratum "C" was found to be approximately 6 inches thick at this point, and superimposed on Stratum "B," which I noted was fairly moist. No artefacts were revealed in Stratum "B."

Report on Photographs of Skull and Fragments of Bone.

I am indebted to Dr. A. Galloway and Mr. L. H. Wells for their preliminary report of the photographs of the skull and bone-fragments sent to the University of the Witwatersrand for examination:

"The photographs suggest a skull which has definite Boskopoid features. There are other features which are definitely non-Boskopoid,as, for example, the size of the mastoid process. The fragments of the radius from the



Sketch No 4

slimness of the shaft suggests a Bush radius, but the massiveness of the lower extremity is definitely non-Bush."

Acknowledgments.

I wish to express my thanks to Professor Dart for the encouragement he has given me to attempt this paper and for his assistance and interest in my work.

My thanks are due also to Mr. and Mrs. Ian Leask of Durban for their valued assistance in connection with the burial at the Karridene site.

I am grateful to Mr. J. F. Schofield, Building Inspector of Borough of Durban, for having surveyed the Karridene site and prepared the necessary maps for this paper.

I am indebted to Mr. E. C. Chubb, Curator of the Durban Museum, for literature lent to me, and to Miss A. Kemack of Durban for preparing my manuscripts.

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FIGURE 1.

No. 1. Polished lance head. Broken. Slight sign of wear through action of elements. Polishing abrasions not definable. No patination. Greatest thickness 11 mm.

No. 2. Polished lance head. Immediate point and butt missing. Polishing abrasions clearly definable. No patination. Greatest thickness 7 mm.

No. 3. Small point made on flake. Four primary flakes were detached prior to removal of point from nucleus. Butt is not faceted. Slight patination. Greatest thickness 7 mm.

No. 4. Small point made on flake. Two primary flakes and a portion of the crust of the nucleus form upper surface of tool. Reduction flakes are suggested on base of implement, presumably for hafting purposes. Butt is partly broken, and shows no faceting. Slight patination. Greatest thickness 12 mm.

No. 5. Small point made on flake. Rough primary flaking and a portion of the original crust of the pebble form upper surface of implement. This crust also forms the butt of the tool and shows no signs of faceting. Slight patination. Greatest thickness 13 mm.

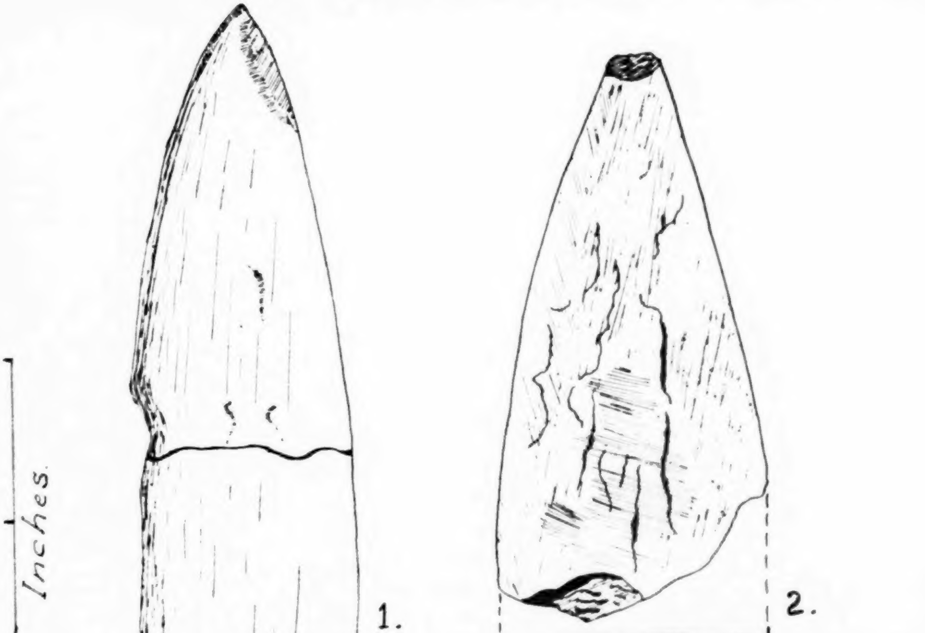

Fig. 1.

FIGURE 2.

No. 1. Wasted side scraper, made on flake. Flat portion of striking platform forms a finger rest. The implement has been sharpened with resolved flaking to its limit, further sharpening being impossible on account of thickness of striking platform. No patination. Greatest thickness 23 mm.

No. 2. Small triangular side scraper made on flake. Flat portion of striking platform acts as finger rest. Cutting edge formed by pressure flaking. No patination. Greatest thickness 10 mm.

No. 3. Side scraper made on flake. Flat portion of striking platform forms finger rest. Cutting edge delicately serrated with pressure flaking. No sign of wear. No patination. Greatest thickness 14 mm.

No. 4. Side scraper made on flake. Three primary flakes have been detached to form upper surface. Portion of crust of nucleus forms finger rest. Butt not faceted. Heavily patinated. Greatest thickness 7 mm.

No. 5. Rough side scraper made on large flake. Original crust of pebble forms reverse side of tool. Resolved trimming used to produce cutting edge. Slightly patinated. Butt not faceted. Greatest thickness 18 mm.

No. 6. Side scraper made from pebble. Three bold flakes have been detached from upper surface. Portion of original crust on extreme right and right front of implement forms finger rest. This crust continues underneath implement, culminating on extreme left on sharp edge of flake. No patination. Greatest thickness 21 mm.

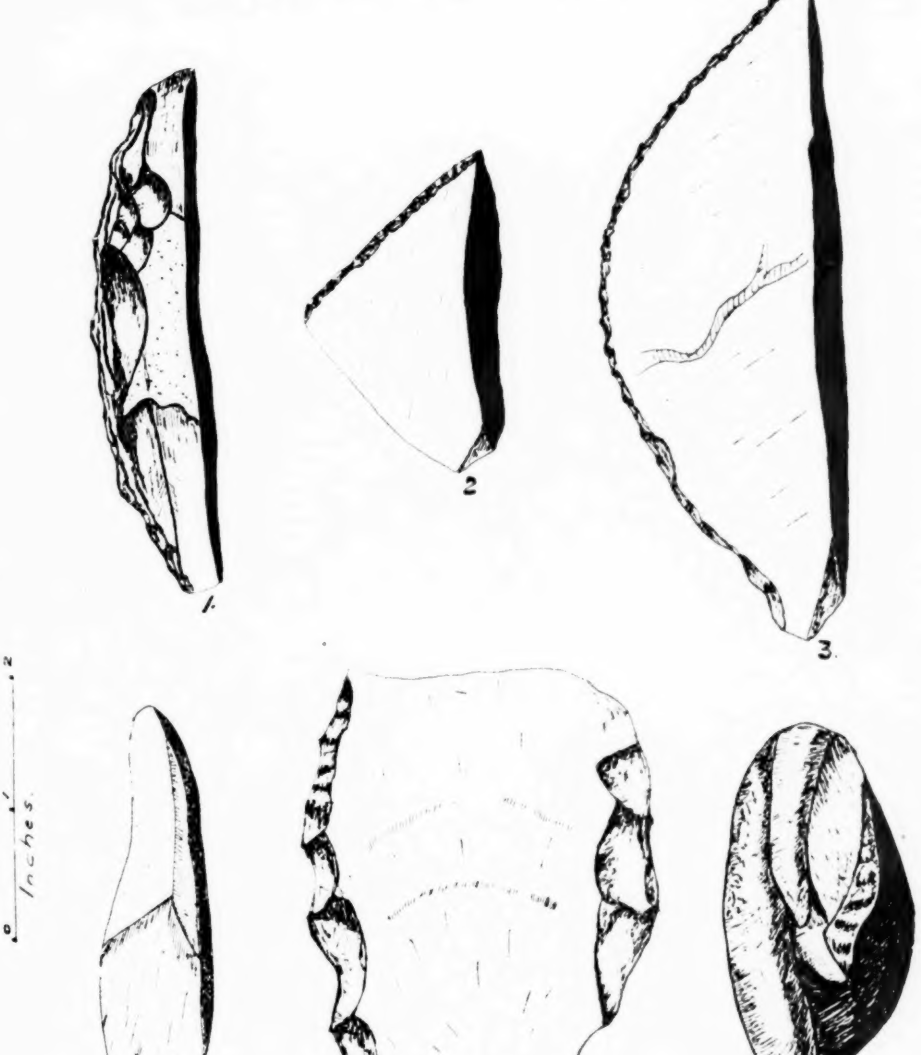

Fig. 2.

FIGURE 3.

No. 1. Large cleaver or chopping tool of Asturian type made on pebble. Bold resolved flaking used to shape tool, with fine resolved trimming to form cutting edge. Portion of pebble crust forms hand grip. No working on reverse side of tool. No patination. Greatest thickness 52 mm.

No. 2. Core scraper. Bold resolved flaking from cutting edge culminates in centre of tool on small platform of original crust of the stone. Base of implement suggests it as having been detached from larger nucleus. Slight patination. Distance from base to platform of original crust 54 mm.

No. 3. Detacher or small cleaver made on water-worn pebble. Bold resolved flaking forms cutting edge, which is also formed by shallow resolved flaking on reverse side of tool. Fractures on butt of implement show hammer stones (or the like) to have been used in working with this tool. No patination. Greatest thickness 37 mm.

No. 4. Pointed chopping tool of Asturian type made on large pebble. Resolved flaking used in shaping tool. Edge is exceptionally keen. Portion of pebble crust forms hand grip. No working on reverse side of tool. No patination. Greatest thickness 33 mm.

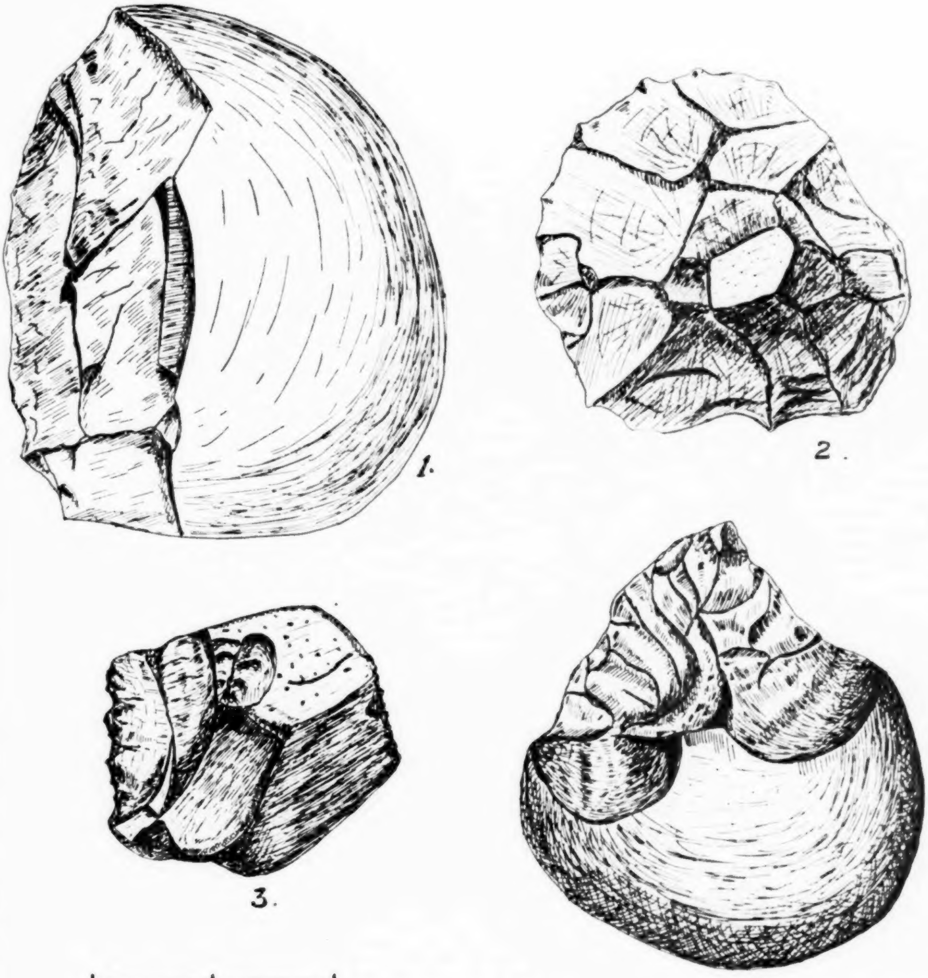

FIG. 3.

FIGURE 4.

No. 1. Perforated chopping tool. Perforation has been worked from either side to centre of tool. Bold resolved flaking from cutting edges to centre of implement shapes the tool and gives it a fair degree of stability. Fine resolved flaking has been used in the sharpening process. The tool shows blunting on a section of the cutting edge which is undoubtedly due to usage. No patination. All working, including the "picking" used for perforation, clearly defined. Greatest thickness 33 mm.

No. 2. Perforated tool. Broken. Perforation has been attempted from either side to centre of tool. A sharp indentation in "unpicked" centre of tool suggests it as having been broken in an attempt to "punch" the centre out prior to completion of perforation. The edges of tool show shallow resolved flaking on under surface, giving the tool a "cup-like" appearance. A red discoloration is noticeable on a portion of the upper surface of tool. No patination. Greatest thickness 29 mm.

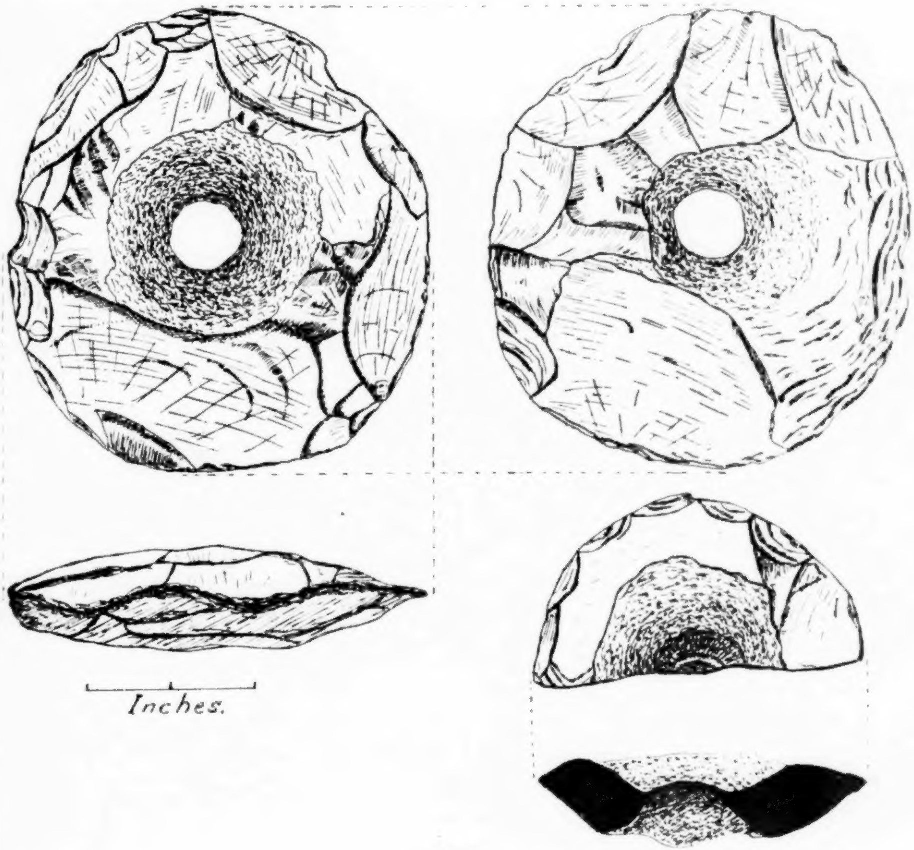

FIG. 4.

FIGURE 5.

No. 1. Grinding stone of close-grained sandstone. Broken. Indentations from grinding are noticeable on upper and lower surfaces to a depth of approximately $\frac{3}{16}$ inch. Greatest thickness 36 mm.

No. 2. Grinder made of sandstone. Two sides of this stone show convex surfaces due to use. These convex surfaces coincide with the concave indentation of Implement No. 1, Figure 5. Greatest thickness 67 mm.

No. 3. Grinder made of sandstone. Slightly sand-pitted. Grinding surface is convex and coincides with concave indentation of Implement No. 1, Figure 5. Depth of implement from grinding surface to butt of tool 76 mm.

No. 4. Polished pestle. Slightly patinated. Greatest diameter 47 mm.

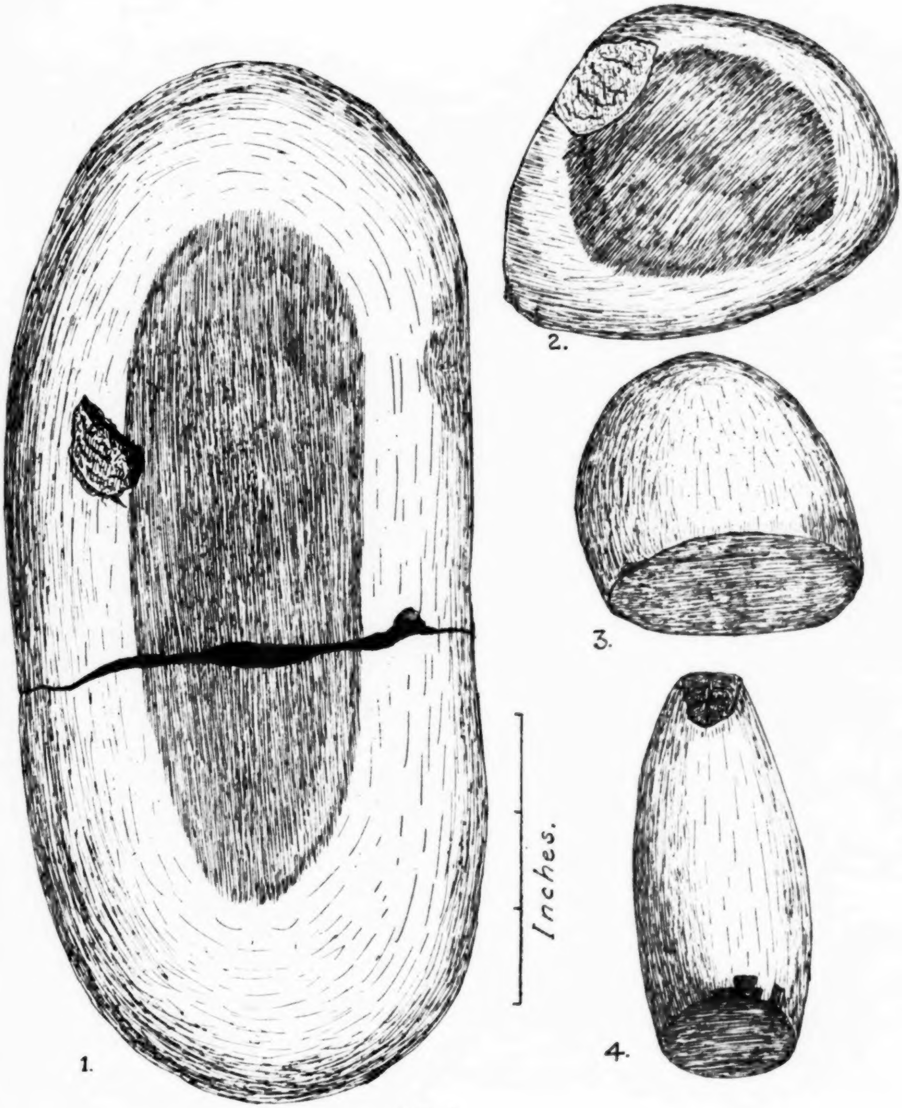

Fig. 5.

REPORT ON THE HUMAN SKELETAL REMAINS FROM THE KARRIDENE SITE.

By ALEXANDER GALLOWAY, M.A., M.B., Ch.B.(Aberd.), and L. H. WELLS, M.Sc.(Rand.), Department of Anatomy, University of the Witwatersrand, Johannesburg.

(Communicated by R. A. DART.)

(With two Text-figures.)

CONTENTS.

1. INTRODUCTION.

The skeletal remains which form the subject of this report were exhumed by Mr. J. Gordon Cramb on an archaeological site at Karridene, Natal. The circumstances of the discovery are fully described in his paper, "Smithfield Implements from a Natal Coastal Site." The remains were forwarded by Mr. Cramb to the Department of Anatomy, University of the Witwatersrand, and are registered in the Department's records as A.386.

Mr. Cramb in his paper recognised three periods in the archaeological history of this site, viz. Middle Stone Age (Glen Grey—Stillbay), Late Stone Age (Wilton—Smithfield), and Iron Age (Bantu). He attributes the human remains to the second of the three periods. It is consistent with this that the remains are mineralised to a slight degree. They comprise a greatly crushed and distorted skull and fragments representing most of the other parts of the skeleton. These prove to belong to a female between 25 and 30 years of age.

2. DESCRIPTION.

(a) *The Skull.*

When exhumed the skull was shattered into many fragments and grossly distorted. It was forwarded to the Department still embedded in the sandy matrix. From this mass the fragments were gradually

extracted and pieced together. In this way it was found possible to restore the greater part of the brain-case and a large portion of the face to approximately their original form. It was found, however, that the relation of the facial and frontal portions to the remainder had undergone a distortion which could not be corrected in the skull as rebuilt. In this reconstruction it was deemed more desirable to restore the correct form of the skull in norma verticalis, which is so important for the racial diagnosis

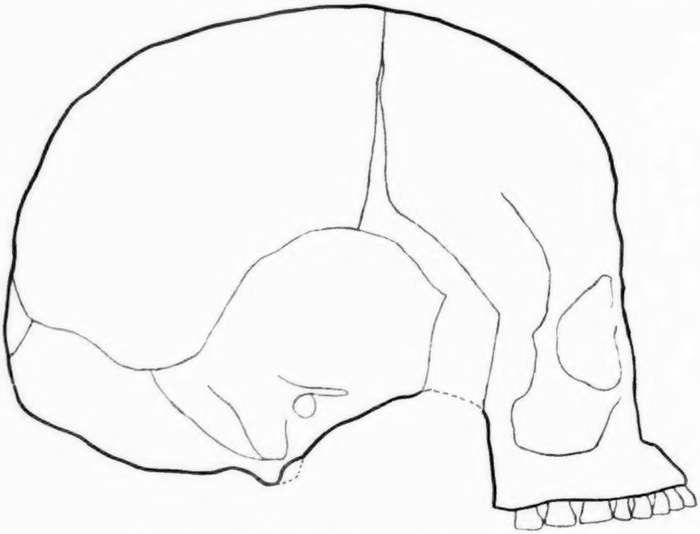

FIG. 1.—Lateral contour of Karridene skull as rebuilt.

of South African skulls, than to place the face in true orientation relative to the brain-case. Owing to the distortion it was not possible to correctly orientate the face without destroying the articulation of the cranial fragments. The appearance of the skull in this state is shown in fig. 1. By attention to anatomical details, however, it has been possible to prepare a tracing of the skull in which this distortion has been eliminated. This tracing, which is here reproduced as fig. 2, represents a close approximation to the original form of the skull.

The skull thus restored is of small size, most of its measurements falling within the Bush range, though a few considerably exceed it. Despite its small dimensions, however, it is massive for a female, and the bones of the cranial vault are of considerable thickness (8–10 mm.). The cranial capacity is estimated at 1270 c.c., and is thus microcephalic. None the

less it exceeds by 200 c.c. the average cranial capacity of the female Bush skulls in this Department.

The cranial form of the skull, according to the Frassetto classification, is ***hypsi-pentagonoid***. It thus has the outline in norma verticalis characteristic of the Bush type, but its relative height greatly exceeds the Bush average, that race being predominantly chamae-pentagonoid (Gear, 1929).

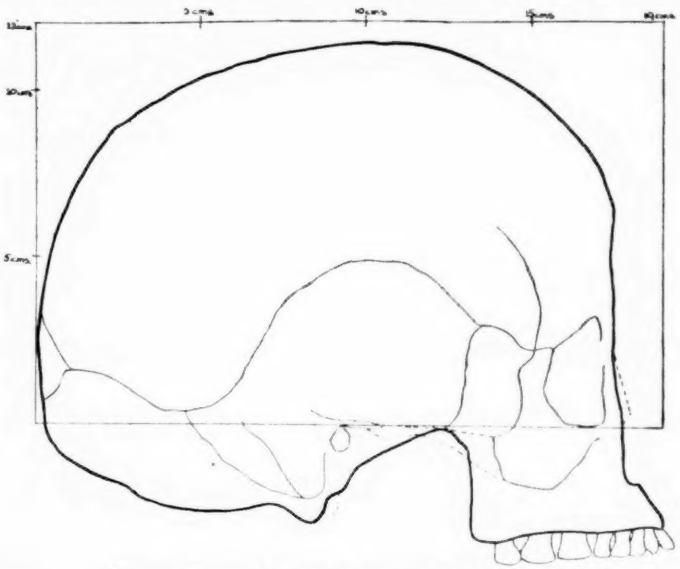

FIG. 2.—Restoration of lateral contour, Karridene skull.

Hypsi-pentagonoid forms do, however, occur among the skulls from South African coastal sites.

Norma Verticalis.—The skull in its original form had a cephalic index of about 75. The outline in this norma is acutely pentagonoid, with very tapering frontal and occipital regions. This form is rather Boskopoid than typically Bush. The degree of frontal narrowing is shown by the fronto-parietal index of 69·9. In consequence of this the frontal bosses, which are prominent, are situated close to the mid-line. In this norma there is no visible metopic ridge, *i.e.* the skull is not of the trigonocephalic type.

The salient frontal bosses conceal the supra-orbital projection in this view. The pre-maxillary region is visible, *i.e.* there is considerable subnasal prognathism. The zygomatic processes of the frontal bone, though

stout, do not project far laterally. The skull appears to have been phaenozygous, which, according to Drennan (1925), is not a Bush feature. In a study not yet published, however, Mr. G. F. Berry of this Department has found phaenozygy to be consistently present in a series of recent Bush skulls. There is a distinct inferior frontal eminence (Wells, 1929) on each side, extending backwards to the stephanion. Behind this point there is a shallow depression leading up to a flattened area behind the coronal suture on each side. This flattening corresponds with that described by Gear (1926, *a*) in the Zitzikama Boskopoid skulls. The parietal bosses are extremely prominent. There is a shallow interparietal groove in the region of the obelion. The occiput tapers sharply to a projecting median boss.

The sutures of the vault are all patent. It therefore appears that the skull belongs to an individual of not more than 30 years of age.

Norma Lateralis.—Fig. 2 shows the form of the reconstituted skull in this norma. The glabella and supraciliary eminences are distinct, but not massive. The supraciliary eminences extend to the middle of the superior orbital margin. The lateral portion of this margin is thickened and everted as in the Matjes River skulls described by Keith (1933). The zygomatic process of the frontal bone is broad at the base, but becomes narrow at its extremity.

A well-marked transverse ophryonic groove separates the supra-orbital prominence from the frontal bosses. These last project forwards to the same plane as the glabella. Above the frontal bosses the median contour of the skull rises in a bold curve to the bregma. Behind this point the vault is flattened and descends slightly, as far back as the parietal boss. It then turns sharply downwards. There is another flattened area in the region of the obelion and lambda. This portion of the contour ends with a sharp change of direction at the inion. That point, however, is not itself prominent. There is a slight transverse occipital groove between the inion and the projecting cerebellar fossae.

Except for the bold curve of the posterior frontal region, the contour of the brain-case is decidedly Boskopoid. Pure Boskop skulls are, indeed, much longer and lower vaulted than A.386. Among the tracings of skulls in the Anatomy Department, however, there is one in which the contour of the brain-case is almost identical with that of the Karridene skull. This skull (A.125) comes from a coastal site at the Hole in the Wall, M'quanduli, Pondoland. It is of Bush type with very strong Boskopoid features, including a considerable degree of trigoncephaly.

The mastoid process is elongated, but it is very narrow antero-posteriorly. It thus exposes a large portion of the area for the attachment of the digastric muscle. The arrangement corresponds with that seen in the temporal bone of Boskop man. There is also a prominent ridge for

the attachment of the sterno-mastoid muscle, such as Galloway (1933) has described in the Nebarara skull. This appears also to be a Boskopoid feature. The supra-mastoid groove and crest are not, however, so well marked as in Boskop skulls.

The tympanic ring is slender. There is a small post-glenoid tubercle. The glenoid cavity is broad and shallow. The root of the zygomatic process is of very slender proportions.

The *mons temporo-sphenoidale* described by Dart (1924) is distinct, but merges into a generalised projection of the squama temporalis. This arrangement is seen in juvenile Bushman skulls and in the Fish Hoek skull. A deep groove separates the temporo-sphenoidal prominence from the inferior frontal eminence, which is continued backwards as far as the stephanion. The temporal line which traverses this eminence becomes sharp only just behind the zygomatic process of the frontal bone.

In the reconstituted skull (fig. 2) the upper part of the face is orthognathous, but there is considerable sub-nasal prognathism. The nasal profile is slightly concave. There is a small nasal spine. The orbits are high, angular in outline, and have very thick, rounded margins. The infero-lateral portion of the orbital margin is very prominent, forming the "orbital shelf" described by Keith in the Matjes River skulls. The zygomatic bone as a whole, however, is slender. There is only a slight infra-orbital depression, continuing downwards into a faintly marked canine fossa. The alveolar portion of the maxilla is massive.

Norma Facialis.—The frontal bone is narrow and high-vaulted, with a distinct metopic ridge. The frontal bosses are prominent. The glabella and supraciliary eminences are not well defined in this norma. The lateral portion of the superior orbital margins is everted. The zygomatic process of the frontal bone is stout, but does not project very much laterally, the difference between the supra-orbital and least frontal diameters being only 8 mm.

The face is much narrower than the average for Bush skulls, giving a leptoprosopic index (56·6). The orbits are correspondingly high, the orbital index being 87. They have the pentagonal outline seen in a number of Bush-Boskopoid skulls. This outline appears to result from the mingling of the high oval Bush orbital form with the lower and quadrangular Boskop form (Wells and Gear, 1931). The interorbital distance is 21 mm. This is formed almost entirely by the nasal processes of the maxillae, the nasal bones being extremely narrow.

The nose, with an index of 57, is platyrrhine, but less so than is usually the case in the Bushman. The inferior margin of the nasal aperture is rounded, with slight nasal gutters. The alveolar region is narrow, and tapers very much anteriorly. There is a slight canine fossa, running up

into the shallow infra-orbital depression. The infero-lateral angle of the orbit is projected into a prominent orbital shelf.

Norma Occipitalis.—The skull is rhomboid in outline, but relatively high-vaulted, the height slightly exceeding the breadth. There is a shallow inter-parietal depression. The occiput is projecting and the inter-parietal portion of the squama occipitalis is a separate bone (*os Incae*). The cerebellar fossae are full. The mastoid processes are long and slender; they do not descend to the level of the cerebellar fossae. The digastric grooves are both broad and deep. The sterno-mastoid ridge forms a very distinct prominence on each side.

Norma Basalis.—The muscular impressions in the nuchal plate are not well marked. The foramen magnum is circular. Sufficient of the occipital condyles is preserved to show that their articular surface was curved antero-posteriorly and faced laterally rather than inferiorly. This type of condyle has been described as Boskopoid by Gear (1926, *a*). The narrow mastoid processes are flanked by enormous digastric impressions. The glenoid fossae are broad, and the articular surface is continued back on to the tympanic plate, another feature which Gear (1926, *a*) regards as Boskopoid.

The dental arcade is narrow (index 101·9) and markedly tapering anteriorly. The palate is deep, but shelving anteriorly. Its posterior part was greatly fragmented, but showed a rugged surface and very prominent *torus palatinus*. All the teeth are present, and all except the third molars are considerably worn.

Mandible.—In conformity with the skull as a whole the mandible is relatively narrow. The ramus is set at right angles to the body of the mandible. It is relatively low and broad (index 69·1). The condyle rises considerably higher than the coronoid process, and the sigmoid notch is shallow. The inferior angle is somewhat everted. All of these are Bush features (Salmons, 1925).

The superior and inferior borders of the body are nearly parallel. The body is not of great thickness. The symphysis shows a chin which is massive but not very prominent. There is a slight degree of alveolar prognathism. The internal surface of the symphysis bears a pit for the attachment of the tongue muscles. Between this and the impressions for the digastric muscles there is a prominent backwardly projecting ridge. This relic of the "simian shelf" must be accounted a very primitive feature, but it is not without parallel in mandibles of Bush type.

(b) *Other Skeletal Parts.*

These were for the most part in an extremely fragmentary condition. The three long bones of the superior extremity (humerus, radius, and ulna)

could, however, be reconstructed sufficiently for anthropological examination. In addition a portion of the ilium was present, and enabled the sex of the skeleton to be established.

Ilium.—The fragment consists of the posterior portion of the ilium, including the auricular surface and the two borders of the sciatic notch. The breadth of this notch indicates that the individual is a female. This is confirmed by the presence of a broad and deep pre-auricular groove. The auricular surface itself is similar to that of the Boskopoid skeleton from Kalomo (Gear, 1926, *b*).

Humerus.—The length of the humerus is 29·6 cm.: the average length of the Bush humeri in the Department is 27·1 cm. The bone is slender, with slight muscular markings. In both humeri the floor of the olecranon fossa is perforated. This condition occurs in all races, but is of unusually frequent occurrence in the Bush race.

Radius.—This bone is also very slender. Its length is 21·4 cm., while the average length of Bush radii is 21·9 cm. The lower end of the right radius is thickened and deformed. The condition appears to be the result of the common injury of the lower end of the radius known as Colles' fracture. This fracture if not reduced leaves a deformity such as is present in this bone. Colles' fracture usually results from a fall on the extended hand. It is an accident that might be expected to occur frequently in a primitive state of life, but we are not aware that an example has previously been described in a prehistoric South African skeleton.

The humero-radial index of this skeleton is 72·3. This is extremely low, approximating the value for the European. The average for the Bush race is 77 (Drennan, 1925).

Ulna.—This bone is slender, but not unusual in shape. Its length is 23·6 cm., the average for the Bush being 23·4 cm. There is no separation between the olecranon and coronoid surfaces of the humero-ulnar articulation, a feature which it has been suggested may be characteristic of the Bushman.

Stature.—The stature estimated from the bones of the arm by Manouvrier's table is 1560 mm. (5 feet 1 in.). This is probably an underestimate, Manouvrier's table being based upon European skeletons, in which the arm-leg ratio is not the same as in the Bush. This stature is, however, 2–3 ins. greater than the average for living Bush women. It may be concluded then that this individual was of greater stature than the dwarf Bush type.

3. Discussion.

The foregoing description has shown that very nearly all of the features of this skeleton are either of Bush or of Boskop type. The characters of

the skull, apart from its dimensions, are predominantly Boskopoid: those of the remainder of the skeleton are Bush, though it has been shown that the individual was of more than Bush stature. The remains may fairly be described as those of a Bush individual with very pronounced Boskop (*i.e.* pre-Bush) features.

There are a few features of the skeleton which do not fit in with our present conceptions of either the Bush or the Boskop types. Such are the height of the brain-case, the narrowness of the face, and the relative shortness of the forearm. It is not impossible that all of these may prove to be within the range of variation of the Bush and Boskop groups. They may, however, represent an intrusive strain of another race. This does not appear to be Bantu. It is more likely to be related to the "Caucasoid" strain found by Dreyer (1933) in the Matjes River skulls.

Very little is known of human skeletal material from the Natal coast. There are only a couple of isolated finds which can be compared with this specimen. Brien (1932) obtained from the Isipofu cave a few fragments, which were interpreted by Wells as Boskopoid. This find, like that at Karridene, was made on a Smithfield horizon. In the Durban Museum there is a "Strandlooper" skull from Doonside, apparently of no great antiquity, the Boskopoid features of which are obvious on a very casual examination.

In the Department of Anatomy there is a fragment of a human skeleton found on the Karridene site by Wells in 1931. This is of Bantu type, and probably comes from the Bantu horizon described by Mr. Cramb. Fragments of another Bantu skeleton were found a few miles farther south, near the mouth of the Umgababa River. These remains were associated with the decorated type of shell-mound pottery described by Chubb and King (1932), but the skeleton mentioned by these observers as found with similar pottery at Sinkwazi curiously enough is of definitely Bush character. The same writers mention that a skeleton found with pottery of the same type on a site at St. Lucia Bay has been determined by Dr. Broom as "Korana."

Attention has already been drawn to the close resemblance between the Karridene skull and one from the Hole in the Wall on the Pondoland coast. This specimen links the Karridene, Doonside, and Isipofu finds with the numerous skulls from the coastal sites of the South-eastern Cape Province. All of these are of the Bush type, often with strong Boskopoid features, and showing in some cases either Bantu or "Caucasoid" strains.

The Karridene discovery confirms the evidence of the Isipofu find, that the Smithfield people of the Natal coast show strong Boskop features. It is still uncertain whether there is in this skull any evidence of another racial type than Bush and Boskop. The very special character of the

"Smithfield" industry of Karridene by itself suggests the possibility of another element in the population.

4. Summary of Conclusions.

1. The Karridene skeleton probably comes from a Smithfield horizon. It is slightly fossilised. The remains are those of a female aged between 25 and 30 years.

2. The remains show a mixture of Bush and Boskop features, the latter being very numerous. There are a few features which cannot at present be assigned to either of these races. These may indicate an intrusion of another type, either Bantu or "Caucasoid."

3. This find, with the scanty evidence previously available, indicates that the Smithfield population on the Natal coast included a strong Boskopoid element.

5. Acknowledgments.

On behalf of the Department of Anatomy we desire to thank Mr. Cramb for submitting this very interesting specimen for examination. Our thanks are further due to Professor R. A. Dart for entrusting this investigation to us, and for his criticism and advice throughout its progress.

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A FURTHER NOTE ON HUMAN SKELETAL REMAINS FROM THE NATAL COAST.

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(Communicated by R. A. Dart.)

(With two Text-figures.)

1. Introduction.

Since the completion of the report on the human skeletal remains from Karridene a further discovery has added considerably to the information, reviewed in that report, concerning the human physical types associated with prehistoric relics in the Natal coastal area.

This discovery was made by Mr. J. F. Schofield in association with Mr. Cramb. These gentlemen found at Tinley Manor, a site on the north coast of Natal, about 45 miles north of Durban, a midden deposit exposed, as at Karridene, by wind erosion of the sand dunes. The midden contained decorated pottery of the type described by Chubb and King (1932). It therefore appears to be contemporaneous with the most recent (post-Smithfield) horizon at the Karridene site. Artefacts similar to those of the Smithfield horizon at Karridene were found within this area, but not definitely associated with the midden. They included rough "Asturian picks" and a fabricator of hippopotamus ivory.

On this site Messrs. Schofield and Cramb found remains of three human skeletons. One of these, however, was clearly an intrusive burial of recent Bantu origin. The other two appeared to be contemporaneous with the midden. It is these remains that form the subject of this note.

The first of these skeletons was that of an adult. It had been buried in the seated position, facing south-west. The left leg bore an iron anklet weighing 19 ounces. The skeleton had been partially exposed by erosion and the skull was badly damaged.

The second skeleton, which was that of a child, had been scattered, and the circumstances of the burial could not be determined. The remains were even more fragmentary than those of the first skeleton.

These finds were submitted by Mr. Schofield to Sir Arthur Keith, and

by him were passed on to Professor M. R. Drennan of the Department of Anatomy, University of Cape Town. Professor Drennan, recognising that the material deserved to be studied in connection with the results of the Karridene investigation, very kindly offered it to the Department of Anatomy of the University of the Witwatersrand for investigation.

2. Description of Material.

The fragments of both skeletons are in a very fragile state and much split and eroded. The bone is desiccated but shows practically no evidence of mineralisation. This feature suggests that these remains are less ancient than the Karridene skeleton.

(a) *Adult Skeleton.*—Of this individual there are fragments representing the greater part of the skeleton. The portions which are sufficiently well preserved to furnish indications of race are the posterior portion of the right side of the skull, two fragments representing the greater portion of the mandible, the shafts of the humerus, radius, femur, tibia, and fibula, and some small bones of the foot.

The state of the teeth and of the sutures of the skull show that the individual was a young adult. No estimate of the sex of the remains is possible.

Skull.—The preserved portion comprises the right temporal bone nearly intact, the lower portion of the right parietal bone, and most of the right side of the *squama occipitalis*. The parietal and temporal fragments are somewhat warped at their broken edges. The fragment clearly formed part of a skull of considerable size, and the bones are correspondingly massive. The thickness of the bones of the vault is from 8 to 10 mm.

In *norma lateralis* the parieto-squamous suture is seen to follow the low-pitched course characteristic of the Bush and Boskopoid types, instead of arching boldly upwards as in the Bantu and European. This formation suggests that the skull was low in proportion to its length. It may be observed, however, that the length of the inferior border of the parietal bone from pterion to asterion is only 92 mm., which is close to the average for Bantu skulls but much less than is usual in Boskopoid specimens.

The mastoid process is large and of considerable downward projection, equalling the average development of this process in Bantu skulls. Only a very small portion of the digastric fossa is exposed posteriorly. There is a slight supra-mastoid groove and a definite supra-mastoid crest, but these features are not as well developed as is usually the case in Boskopoid skulls. The tympanic ring is thick and rugged, as in the Bantu; in Boskopoid individuals it is often disproportionately slender. The root of the zygomatic arch is stout, but not so massive as that of the Boskop and Nebarara skulls (Galloway, 1933).

The sagittal contour of the skull has been disturbed by warping. It can be seen, however, that there was a flattened area between the obelion and the lamba and that the occiput was rounded.

In *norma occipitalis* the most characteristic feature is a pronounced depression above the asterion. Above this depression the parietal bone swells out boldly. This formation is characteristically Boskopoid. This view also shows the development of the supra-mastoid groove and crest and the downward projection of the mastoid process.

In *norma basalis* the muscular impressions on the occipital bone are seen to be moderate in development. The digastric fossa is deep and narrow. The glenoid fossa is deep and resembles that of the Bantu. The post-glenoid tubercle is not as large as is usual in Boskopoid skulls.

The *internal aspect* of the fragment is chiefly remarkable for the very deeply excavated groove for the sigmoid sinus. The dimensions of this groove are equalled only in the Boskop and Kalomo skulls.

Mandible.—The fragments comprise both sides of the body and part of the right ramus. This specimen exceeds in every dimension the average measurement recorded by Shaw (1931) for the Bantu. The minimum height of the ramus is 50 mm., the maximum height must have been at least 55 mm. The depth of the symphysis is 34 mm., and that of the molar region 30 mm. The thickness of the molar region is 20 mm., exceeding the maximum found by Shaw in the Bantu. The dental length is 52 mm.

In the massiveness of the molar region this mandible is most nearly comparable with the Boskop fragment. Further, in the majority of its measurements it is closely comparable to the mandible of the Boskopoid skeleton from Kalomo described by Gear (1926). The Kalomo mandible is slightly larger than that of the Tinley Manor skeleton, but it is actually somewhat less massive in construction.

Fig. 1, A, represents the lateral aspect of the Tinley Manor mandible. In this view the ramus of the mandible is obliquely placed in relation to the body. The inferior margin of the body has an evenly convex contour. There is a massive chin and a slight degree of alveolar prognathism.

Viewed from above, the dental arcade is similar to that of the Bantu, and less narrow than that of the Kalomo mandible. The teeth are not heavily worn. There are two slight ridges on the posterior surface of the symphysis for the attachment of the genial muscles.

In fig. 1, B, the contour of the Tinley Manor mandible is compared with that of the Kalomo mandible. The comparison reveals the close similarity in the size and form of the body between these two specimens, the only difference being in the dimensions of the ascending ramus.

Other Skeletal Parts.—The *humerus* is not completely preserved. The fragment is longer and stouter than that of an average Bushman. The

olecranon fossa is not perforated. The *radius* also is larger and stouter than that of the Bushman.

The *femur* is sufficiently complete to permit of an estimate being made

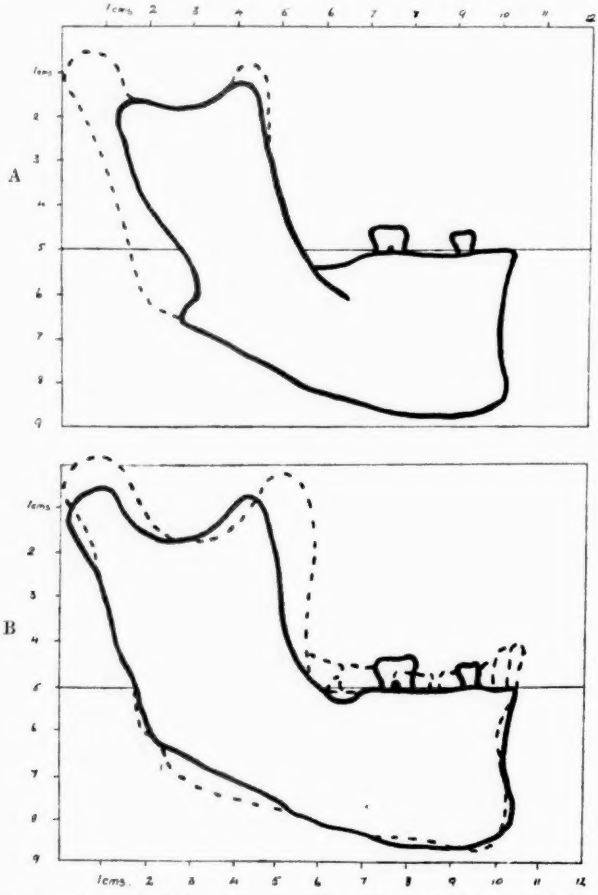

Fig. 1.—A. Lateral aspect of the adult mandible. The restored portions indicated by the interrupted line. B. The restored mandible (continuous line) superimposed upon the outline of the Kalomo mandible (interrupted line).

of its original length. This was about 450 mm., corresponding to a total stature of 1670 mm., or about 5 feet 6 inches. Clearly the individual was not of the dwarf Bushman type. The shaft of the femur is moderately

robust. There is a slight third trochanter and a pronounced hypotrochanteric fossa. The platymeric index is 82·8 and the pilastric index 111·8. Both these figures are intermediate between the values found in the Bantu and in Bush and Boskopoid types.

The *tibia* is very incomplete. The fragment appears slender. The platycnemic index is 68·7, which again is intermediate between Bush and Bantu figures. The hollowing of the lateral surface, described by Gear in the Kalomo skeleton, is not present in this individual. The *fibula* is also incomplete; the fragment present is robust.

The *bones of the foot* which are available for study are the first cuneiform and first metatarsal bones. The former agrees in its dimensions with that of the Bushman, and is much smaller than the average Bantu. The latter, on the other hand, is larger than the recorded maximum for the Bushman. It is, however, of more slender proportions than is usual in the Bantu.

Summary.—Certain of the features of this skeleton are definitely Bantu. A greater number, however, are either Bush or Boskopoid. The influence of the massive Boskopoid type appears stronger, especially in the mandible, than that of the dwarf Bushman.

(b) *Juvenile Skeleton.*—Only the skull and mandible of this individual are susceptible of a definite racial diagnosis. The remains are those of a child of over 6 years, the first permanent molars being erupted in both the upper and lower jaws. The exact age is, however, a little uncertain owing to the anomalous eruption of the permanent incisor teeth. In the mandible none of these teeth have commenced to erupt, but in the maxilla the eruption of the median incisor is nearly complete and that of the lateral incisor has just commenced. Thus the maxillary dentition suggests an age of about 7 years, while that of the mandible is at the 6-year stage. The higher age is most probably the correct one. No estimate of the sex of the skeleton is possible.

Skull.—Of this there are present the occipital bone, the inferior portions of the two temporal bones, the sphenoid, the palatines, the maxillae, and the infra-orbital portion of the frontal bone.

In *norma lateralis* the occipital boss is prominent, and is separated by a broad transverse occipital groove from the cerebellar fossae, which are also prominent. This contour is much more similar to that of Bush than to that of Bantu skulls of this stage of development. The posterior portion of the parieto-squamous articulation is preserved, and shows the very depressed Bush contour. The tympanic ring is more slender than in juvenile Bush skulls.

The supra-orbital region is flat, as is the case in both Bush and Bantu skulls of this age. The facial profile is nearly vertical, except for some subnasal prognathism. It thus resembles the Bush much more than the

Bantu. The very flat nasal profile is also Bush. The length of the face is 53 mm., which is intermediate between that of Bush skulls at this age (48 mm.) and that of Bantu skulls (57 mm.).

In *norma facialis* the supra-orbital region is smooth, and there is no indication of a metopic ridge. The length of the nose (39 mm.) is again intermediate between those of Bush and Bantu. The nasal aperture is, however, very broad, giving an index of 58·9, which is close to that of the Bush child (57·8), but far removed from that of the Bantu (50·6). The nasal bones are narrow, and very flat, as in the Bush, not ridged as in the Bantu

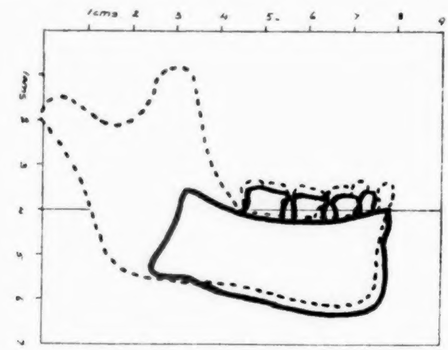

FIG. 2.—Lateral view of the fragment of the juvenile mandible (continuous line) superimposed upon that of a Bantu child aged 7 years (interrupted line).

skull. The erupting permanent incisors are very crowded, the median teeth covering nearly the whole breadth of the laterals.

In *norma basalis* the foramen magnum is large and lozenge shaped, resembling those of some Bush skulls. The glenoid fossae are shallow, and resemble the Bush more than the Bantu type. The post-glenoid tubercle is large. The palate is relatively narrow and deep, in this resembling the Bantu rather than the Bush.

Mandible.—The fragment consists of the whole of the body on both sides. Both rami are missing. In dimensions it is equal to the most massive of Bantu mandibles at this age, considerably exceeding the Bush mandible.

In fig. 2 the fragment is superimposed in *norma lateralis* upon the mandible of a Bantu child aged 7 years. The comparison shows that the inferior border is more evenly convex in the fragment than in the Bantu mandible, giving it a more robust appearance. In addition the mental protuberance of the fragment is seen to be considerably more prominent than that of the Bantu mandible. It is true that this prominence is ac-

centuated by the slighter degree of alveolar prognathism present in the fragment, which might be modified by the eruption of the incisor teeth. However, even if the alveolar region were advanced to the same degree as in the Bantu mandible, and this is the maximum effect which could possibly be produced by the eruption of those teeth, the greater prominence of the mental region would still be obvious.

The Bush mandible at this stage of development has been shown (Wells, 1931) to differ from that of the Bantu not only by its smaller dimensions, but also by the smaller mental protuberance and less degree of alveolar prognathism. Since the mental protuberance of the Tinley Manor fragment exceeds that of the Bantu, it appears that this feature of the fragment is not Bush. It and the massiveness of the whole fragment may be regarded as Boskopoid.

In *norma verticalis* the fragment has a much narrower dental arcade than the Bantu mandible. This is in agreement with the narrowness of the palate and the crowding of the upper incisors, which is probably to be correlated with the non-eruption of the lower incisors. The cusps of the deciduous and first permanent incisors are more similar to those of Bush than to those of Bantu specimens. The symphyseal region is massive, and has on its posterior surface a large genial fossa.

Summary.—The remains of the brain-case of this skull present predominantly Bush features. The elongation of the face and the form of the palate, however, are not Bush. These features may be Bantu. On the other hand, the massive mandible with its very prominent chin is neither Bush nor Bantu in type, but appears to be Boskopoid.

This skull thus proves to be of the same mixed type as the adult skeleton, but the Bush element is more pronounced. It is probable that the narrowing of the dental arcades and consequent crowding and mal-eruption of the teeth are due to this mingling of racial types of very different physical development.

3. Discussion.

This analysis has shown the two Tinley Manor skeletons to be of mixed type, combining in different proportions Boskop, Bush, and Bantu features. The presence of the latter in unmistakable form distinguishes these remains from the Karridene skeleton.

It has already been pointed out that the Tinley Manor remains are derived from a post-Smithfield horizon. It may therefore be supposed that the appearance of the Bantu element in the population coincided with that of the iron- and pottery-using post-Smithfield culture. This is further borne out by the iron anklet associated with the adult skeleton. This confirms the evidence reviewed in the report on the Karridene skull, that some

of the human remains found on pottery-yielding post-Smithfield sites are of Bantu type, though others are Bush or "Koranna."

A similar conclusion is suggested by a consideration of the mode of burial of these skeletons. The adult from Tinley Manor was buried in the seated or upright-contracted posture. This practice is characteristic of the Bantu, whereas the Bush peoples usually employed the horizontal-contracted posture. The Karridene skeleton was buried in the latter manner.

It may therefore be concluded that the introduction of the post-Smithfield culture characterised by iron-working and elaborately decorated pottery was the work of a people at least partly of Bantu type. These intruders did not, however, displace the Bush-Boskopoid people of the Smithfield period. Instead, they mingled with them, producing the mixed type represented by the Tinley Manor skeletons.

The persistence of the Boskopoid physical type, in spite of this succession of new racial influences, is most striking. In this respect the finds from the Natal coast, scanty though they are, are in complete agreement with the more extensive evidence from the Cape Province.

4. Conclusions.

1. The skeletons from Tinley Manor are those of a young adult and a child of about seven years. They are not appreciably fossilised. The adult had been buried in the seated posture. These remains come from a pottery-yielding midden and are associated with iron-work. They are therefore post-Smithfield.

2. The adult skeleton shows a mingling of Bantu with Bush-Boskopoid features, the Boskopoid element being stronger than the Bush. The juvenile skeleton is predominantly Bush, with some Boskopoid and some apparently Bantu characters.

3. This find confirms the fragmentary evidence previously available that the post-Smithfield metal-working and pottery-using culture was introduced into this area by people at least partly of Bantu type. These mingled with the Bush-Boskopoid people of the Smithfield period. The persistence of the aboriginal Boskopoid element through all later changes of population is as striking in the Natal coastal area as in the Cape Province.

5. Acknowledgments.

On behalf of the Department of Anatomy I wish to thank Professor M. R. Drennan for placing this most instructive material at our disposal. Further, I have to thank Professor R. A. Dart for entrusting this investigation to me, and for his criticism and advice during its progress; also Dr. A. Galloway

for checking over the manuscript. The diagrams to illustrate this and the previous paper have been prepared by Mr. W. J. Beukes, Laboratory Assistant in the Department.

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A NEW VARIATION OF SMITHFIELD CULTURE FROM A CAVE ON THE PONDOLAND COAST.

By E. C. Chubb, G. Burnham King, F.R.C.S.(Ed.), and A. O. D. Mogg, M.A.

(With Plates VIII–XI, three Diagrams, and five Text-figures.)

(Read March 21, 1934.)

The existence of a cave at the mouth of the Umgazana River, some ten miles south-west of Port St. Johns, that might provide evidence of prehistoric occupation, was brought to the notice of Dr. King, who visited it in October 1932 and, during a few days' stay, dug a trial trench through the thick deposits that were found on its floor. The results provided abundant evidence of prehistoric occupation, and indicated very clearly that the cave was worthy of thorough investigation. For this purpose Messrs. Chubb and Mogg spent nine days on the site, from 29th December 1932 to 6th January 1933.

To reach the mouth of the Umgazana River necessitates a journey of twenty miles by road from Port St. Johns to the Umgazana Trading Store, and a journey of three miles by boat down the river.

The cave is situated on the seashore (Plate VIII, Photo A), in a dense forest of the wild banana (*Strelitzia augusta*) covering a headland composed mainly of Molteno sandstone, capped by Lower Cretaceous rock; for in this area a fault of considerable magnitude has brought down the Beaufort Series and the Molteno Beds, the lowest of the Stormberg Series, to sea-level. The floor of the cave is of Karroo dolerite, which is intrusive at and near the line of junction of these two rocks. The cave faces south-east, and the floor at its entrance is only 7 feet above present high water at spring tides. It appears to have been excavated by wave action, during the erosion of the wave-cut terrace 10 to 14 feet above present sea-level, evidence of which exists at Durban, and subsequent to the formation of the terrace 20 feet above present sea-level, evidence of which may be seen all along the South African coast (*vide* L. J. Krige, Trans. Geol. Soc. S. Afr., vol. xxxv (1932), p. 66; and S.A. Journal of Science, vol. xxix (1932), p. 34; and Du Toit, Geological Survey, Explanation of Cape Sheet No. 28, Pondoland (1920), p. 40).

The cave is a funnel-shaped aperture in the Molteno sandstone, 20 yards wide at the entrance. It narrows to 9 yards in width at 5 yards from the entrance, and is 7 yards wide at 17 yards from the entrance.

The floor slopes upwards from the entrance, rising 11 feet in 50 feet, and the roof slopes downwards, dipping north-eastwards. The full depth of the cave could not be ascertained, because at 20 yards from the entrance there is only a space of about 2 feet between floor and roof. It is shown in plan in Diagram I, and in section in Diagram II.

From a glance at the longitudinal section (Diagram II) it may be seen (*a*) that the earliest occupations were well within the cave, behind a transverse barrier of dolerite boulders at yard-peg 9, the strata being slightly basin-shaped; (*b*) that the next series of occupational strata were mainly well forward, but also extended backward over the whole length of the cave, the strata lying obliquely forward and more horizontally backward, where they overlap and conceal the earliest deposits; and (*c*) that the two latest occupational layers were relatively far back within the narrowed portion of the cave.

Methods of Excavation.

The trial trench made by Dr. King through the deposits was about 5 feet wide, and extended from the entrance to a point about 9 yards from it. He excavated to the floor of the cave. He took note of each of the layers encountered and retained all the objects he recovered from them. Before leaving he took the precaution to fill in the trench with the material excavated from it.

When Messrs. Chubb and Mogg arrived to continue the work of excavation they first reopened the trench made by Dr. King, and then extended it to the back of the cave. On the right, *i.e.* north, wall of this trench the deposits were then exposed in vertical section, the maximum depth being 8½ feet. A continuous series of four photographs of this section were taken, two of which are reproduced, viz. Plate VIII, Photo B, and Plate IX, Photo C.

In order to make a drawing to scale of this section, to serve as a basis for the work of excavation, a tape measure was laid from a base-line at the entrance along the floor of the trench to the back of the cave. Wooden pegs were then inserted at yard intervals along the bottom of the section, and similar pegs were placed over them at the top of the trench by plumb-line verticals. Along these verticals additional pegs were placed at 1-foot intervals (see Plate IX, Photo D). This enabled the strata to be depicted with accuracy. A drawing to the scale of 1 inch to 1 yard was then made, which is reproduced in Diagram II, and the various strata were numbered consecutively.

The work of excavation was carried out stratum by stratum (Plate X, Photo E), according to the relationship revealed by the diagram of the trench section. The material was removed with a spade, the flat blade being inserted horizontally, and each spadeful carefully searched. It was then thrown in such a manner that the material was thinly spread on the ground, when it was again thoroughly searched. On all objects recovered the number of the stratum from which they were obtained was immediately written on them. When it was considered desirable, the material excavated was passed through a large sieve of half-inch mesh.

The deposits on the left of the trial trench were not excavated, but were left intact for the benefit of those interested in the subject who may visit the cave in the future.

The artefacts and other objects recovered from the cave have been deposited in the Durban Museum.

Stratigraphy.

The stratigraphical sequence of the occupational layers was particularly well defined; for although the relationships of some of the strata, as seen in the diagram of the longitudinal section of the trench (Diagram II), in one or two places appear obscure, yet on excavation the apparent obscurity was readily elucidated. For instance, the "disturbed site" between yards 12 and 13 introduced a definite confusion; but when this local area was examined and removed before the main excavation of the cave was proceeded with, the stratigraphical relationship of the strata horizontally was readily established. At no point during the excavation was the horizon of any layer in doubt.

In the account which follows, the diagram of the longitudinal section of the trench (Diagram II) is used both for numbering the sequence of the layers and giving their extent by quoting the yard-pegs between which each stratum occurred.

Stratum No. 1 (from yards 7 to 8, 9·3 to 10·3, and 10·7 to 16).—This consisted of ochre-coloured sand lying on the floor of the cave and varying in thickness from 6 to 12 inches. Its colour indicated that it had been solely derived from the roof and walls of the cave.

It must have taken a considerable period of time before the cave, when raised from the ocean-bed some 8 miles seawards from the former shoreline (*vide supra* du Toit), was discovered and occupied by prehistoric man, in order that the cave floor could be covered to such a depth with sand derived from the weathering action of moist air on the roof and walls.

Apparently all the deposits forward of yard 7 were worn away by the later occupants of the cave; and it is almost certainly due to the occurrence

of the transverse line of dolerite boulders between yards 8 and 9 right across the cave which saved the stratum beyond yard 9 from a similar fate.

This lowermost stratum was sterile except in one spot where, between yards 10 and 12 and at a level at least 3 inches above that of the cave floor, a few scattered shells of the large mussel (*Mytilus edulis*) and stone implements were found.

These occurrences of objects were almost certainly connected with the disturbance in the original deposit indicated by the obliquely ascending fireplaces and ashy sand seen between yards 9 and 11.

Stratum No. 2 (between yards 8 and 9).—This was 8 to 12 inches at the trench edge: it diminished rapidly, and vanished 6 feet from the north trench wall. It was a local deposit amongst the dolerite boulders, and consisted chiefly of mussel shells (*Mytilus edulis*) with a few shells of *Gasteropoda*, amongst which was a considerable proportion of fish bones and fish scales, with an occasional clump of vegetable wool, the remains of sea-grass (*Zostera capensis*). A few stone implements, side-scrapers of various form, were found, but no bone tools or potsherds.

This deposit rested on the floor of the cave, and was the earliest occupational layer.

Stratum No. 3 (between yards 8 and 10·7).—This was an ash layer, ascending obliquely upwards and outwards, and becoming a definite fireplace, 4 inches in average thickness between yards 10 and 11.

It contained neither shells nor artefacts, and was separated by distinct thicknesses of sand between shell layers 2 and 4. However, on account of its position and the occurrence of ash-infiltrated sand above it, it was considered to be related to, *i.e.* a lowermost fireplace of, stratum 4.

Stratum No. 4 (between yards 7 and 16).—This was an occupational layer of considerable magnitude and importance, and the largest of the earlier strata. It was composed chiefly of mussel shells (*Mytilus edulis*) interspersed with fish bones and scales.

The stratum covered the whole width of the cave and was of astonishing depth. For whereas between yards 7 and 10 it measured only 2 to 4 inches in thickness, it increased to 10 inches between yards 11 and 11·5, and no less than 2½ feet at yard 15. Beyond that it rapidly diminished to an inch at yard 16, where it was noted it had 6 inches of ochre (cave) sand below it extending to the floor of the cave, and 2½ feet of the same material above it reaching to the surface. That is to say, that from yard 15 to where it vanished at about yard 17 it had no occupational strata either below or above it. It was also noted during the course of the excavations that it merged, near the right (north) wall of the cave, into strata 12 and 14, where these occupational layers arched down to meet it, following the curvature of the roof at that point.

This layer was also remarkable for the amount of animal and vegetable remains it contained, as well as the number and variety of the artefacts revealed. Amongst the bones were recognised the jaws of a monkey and portions of the limbs of antelopes. The vegetable material consisted of strands and masses of the sea-grass (*Zostera capensis*) in an excellent state of preservation.

The implements consisted of (*a*) pointed wooden pegs; (*b*) bone awls, points, and needle-like implements; (*c*) stone implements in the form of side-scrapers, some of which had the very finely trimmed cutting edge produced by pressure flaking, a burin, a notched scraper or spokeshave, a large circular scraper and concavo-convex scrapers, also a grinding stone.

This was the first or earliest occurrence of burins in any stratum.

Stratum No. 5 (between yards 8·6 and 12·6).—This consisted chiefly of ash, or sand much discoloured and impregnated with ash, and occurred to a variable extent across the cave floor.

Between yards 9 and 10 the layer was of dark and light streaks of ash-impregnated sand, 11 inches in thickness, which at yard 11 had increased to 14 inches, after which to yard 12 it was 2 feet in depth. One portion, 12 inches in thickness, continued under the "disturbed area" between yards 12 and 13. In this latter portion the material was almost entirely ash, two large areas being quite white. Above the upper white fireplace a dark ash band curved up obliquely between yards 11 and 12 to meet stratum 6.

When the "disturbed site" had been cleared it was found that these extensive fireplaces rested directly upon stratum 4, but arched upwards into the pure fish layer seen in the trench section beyond yard 13.

Hence there were the fireplaces for stratum 6, which in all probability extended beyond yard 7, as indicated by the continuation of this ash stratum below, as also the abruptness of termination of the mussel-shell layer where the oblique layers of stratum 11 cut this off, at yard 9.

Stratum No. 6 (between yards 10 and 11, and 13 to 14·7).—Between yards 9 and 11 this consisted chiefly of mussel shells, amongst which were some stone implements, mostly side-scrapers, and was of an average thickness of 10 inches. When the disturbed area was cleared away this shell layer gradually narrowed and became continuous with the fish layer represented between yards 13 and 14·7. At peg 13 this was about 4 inches in thickness, and from thence it tapered to nothing. In this latter region it consisted almost entirely of fish bones and scales, amongst which was found the tusk of a wart-hog.

Stratum No. 7 (between yards 9·5 and 12, and 13 to 14).—This consisted chiefly of ash in a broad strip arching upwards, 9 inches in thickness at yard 9·5, where it merged into a diamond-shaped mass between yards 9

and 11, 12 inches in thickness, and an oval fireplace between yards 11 and 12, which was of an average thickness of 12 inches. Beyond the disturbed site this stratum was composed chiefly of ash-impregnated sand, 8 inches in thickness at yard 13, tapering to vanishing-point at yard 14.

No artefacts were found in this stratum.

Stratum No. 8 (between yards 12 and 14).—This was a disturbed area which, between yards 12 and 13, was a basin-shaped excavation, 3½ feet in depth at yard 12, and 2½ feet at yard 13 (see Plate IX, Photo C). It continued as a narrow tongue of red spongy material to yard 14·5. The lowermost portion of this excavated area consisted of a mixture of grey sand, strands of sea-grass (*Zostera capensis*), a large number of dolerite pebbles up to 4 inches in diameter, and a few mussel shells evenly dispersed. Above this was a compact layer about 3 inches in thickness, composed chiefly of folded leaves and stalks of the wild banana (*Strelitzia*) in an excellent state of preservation, sea-grass (*Zostera capensis*), and mussel shells. Above this was a thickness of 18 inches of the brick-coloured spongy material, obliquely through which, just above the basin-shaped excavation, was a further layer, ½ inch in thickness, of folded Strelitzia leaves. Contrary to our expectations, no human remains or artefacts of any description were found in this disturbed site, and we can offer no explanation for its remarkable occurrence.

Stratum No. 9 (between yards 6·6 and 9).—This consisted chiefly of ochre (cave) sand, with streaks of ash parallel to its inclination between yards 8 and 9. It varied in thickness from 6 to 14 inches and sloped obliquely upwards, terminating abruptly at yard 9·5. It yielded no artefacts.

Stratum No. 10 (between yards 5 and 9·3).—A layer of mussel shells, ½ inch to 4 inches in thickness, parallel to stratum 9, in which a few stone implements were found.

Stratum No. 11 (between yards 4 and 9).—This consisted of ochre (cave) sand extending from the cave floor at yards 4 to 6, narrowing abruptly at 3 feet from the floor at yard 8 into an oblique strip underlying stratum 12. Loose mussel shells were found scattered throughout the portion between yards 5 and 7, but at a height 6 inches from the cave floor.

Stratum No. 12 (between yards 2 and 16).—This consisted of an extensive layer of shells, principally mussels (*Mytilus edulis*) of uniformly large size between yards 4 and 9, after which it was mainly composed of fish scales and bones. This, and the strata above it, were particularly well defined. It commenced with a fireplace between yards 2 and 5, at which latter point it attained its greatest thickness, viz. 18 inches. A further fireplace occurred between yards 9·5 and 11. It extended over the whole area of the cave, merging at the right wall into stratum 13.

It contained jaws and bones of antelopes, ribs of buffalo, and jaws of wild pig. Of artefacts, it contained (*a*) pointed wooden pegs; (*b*) bone points, awls, and needle-like implements, portions of a buffalo rib used in trimming stone implements by pressure; (*c*) stone implements in the form of concavo-convex scrapers (one retrimmed), notched scrapers, side-scrapers (some with edges produced by pressure flaking), etc., a grinding stone, a complete stone ring, a broken portion of a second stone ring, and (*d*) a single nacre disc.

Three human burials into this stratum were found, but the bones were so disintegrated as to render them useless for preservation and identification. They were buried in the foetal position with the head abutting on the cave wall. Immediately above each burial the strata had been disturbed.

No pottery was found in this stratum.

Stratum No. 13 (between yards 4·3 and 8·7).—This consisted of ochre (cave) sand, 4 inches in average thickness, in which only one or two stone implements were found.

Stratum No. 14 (between yards 5 and 9).—This consisted chiefly of shells of ***Mytilus edulis***, together with ***Haliotus natalensis***, ***Patella rustica***, and ***Patella sanguinea***, with large quantities of fish bones and scales. Bones of antelopes, wild pig, and jaws of Mussel Crusher (***Pagrus nasutus***) occurred in it. It was roughly parallel to stratum 12, and merged into it at yard 9, where the strata were horizontal. Whilst this stratum was only 1 inch thick in the centre of the cave, it was found on excavation to develop into a layer of considerable extent and importance. On the right wall of the cave it was 12 inches thick, and here it merged into stratum 10 below and stratum 12 above.

The artefacts obtained from this stratum consisted of (*a*) potsherds; (*b*) bone points, awls, needle-like implements, and a unique implement shaped like a packing-needle; (*c*) stone implements in the form of side-scrapers, notched scrapers, burins, and trimming stones; and (*d*) pointed wooden pegs.

It should be noted that this was the earliest stratum in which pottery was found.

Stratum No. 15 (between yards 4 and 8·8).—This was a short stratum of ochre (cave) sand, of an average thickness of 6 inches, devoid of shells or other food remains and artefacts, with the exception of a bone needle-like implement which may have been trodden into it.

Stratum No. 16 (between yards 2 and 12).—This was a stratum of shells and fish remains. It was only 3 inches in thickness on the trench wall, but rapidly developed to 12 inches in thickness, and extended right across to the north wall (see Plate X, Photo F), at which point it merged into stratum 26.

The shells consisted chiefly of mussels (*Mytilus edulis*), with which were *Haliotus natalensis*, *Patella rustica*, *Patella* sp., *Cypraea* sp., and *Ostraea* spp. Some portions of this stratum, especially towards the north wall, consisted almost entirely of fish bones and scales, in which were many jaws of large Mussel Crushers up to 18 lb. in weight, together with fireplaces. Of other food remains it contained bones of antelopes and wild pig. Masses of sea-grass (*Zostera capensis*) were also encountered.

The artefacts obtained consisted of (*a*) pottery; (*b*) bone points and awls; and (*c*) stone implements, viz. a burin, concavo-convex scrapers, large circular scrapers, notched scrapers, and side-scrapers.

Stratum No. 17 (between yards 1·3 to 12).—This consisted of a non-occupational layer of ochre (cave) sand of considerable extent, and varying considerably in thickness, *i.e.* between yards 1·3 and 10 it was 2 to 8 inches in thickness, at yard 11 it was 18 inches, and at yard 12 it was 12 inches, where it abruptly terminated at the "disturbed site." Large portions of this stratum consisted of sand impregnated with ash, merging into fireplaces of pure ash. In the latter sections the jaw of an antelope, a bone awl, bone points, fragments of pottery, and some stone implements were recovered. The stone implements consisted of side-scrapers, and a small trimming stone.

Stratum No. 18 (between yards 5 and 12).—This was a layer, from 3 to 6 inches in thickness, consisting of ash between yards 5 and 8, terminating in a large fireplace; and beyond this, *i.e.* between yards 9 to 12, consisting of shells, of which the chief were *Mytilus edulis*, *Patella rustica*, *Haliotus natalensis*, and *Ostraea* sp. In the ash areas were large accumulations of fish scales and bones. On excavation an additional large fireplace was encountered, 3 feet from the north wall of the cave. In addition to the shells, the only food remains that were found consisted of the jaws of a rock rabbit; but potsherds and one or two stone implements were recovered.

Stratum No. 19 (between yards 5 and 7·8, and 9 to 10·2).—This consisted of a narrow layer of ochre (cave) sand, which, although only 1 inch in thickness as exposed in the trench section, was found on excavation to develop to 8 inches at the north wall. A bone awl and one or two stone implements were found in it.

Stratum No. 20 (between yards 5 to 7·7, and 8·7 to 10).—This was a thin layer, ½ to 2 inches in thickness, consisting chiefly of fish bones and scales, amongst which were shells of *Mytilus edulis* and *Haliotus natalensis*. A large fireplace occurred opposite yard 9, and a large sandstone pebble opposite yard 7, near the north wall. No artefacts were encountered in this stratum.

Stratum No. 21 (between yards 5 to 7·5, and 9 to 10).—This consisted of a sterile layer of ochre (cave) sand of an average thickness of 6 inches.

Stratum No. 22 (between yards 5 to 7·4, and 8·6 to 10·2).—This consisted very largely of fish remains, together with shells of *Mytilus* and *Haliotus*. It was ½ to 2 inches in thickness in the forward portion, and merged into a large diamond-shaped fireplace of white ash between yards 7·4 and 9. On excavation it was found to develop to 6 inches in thickness towards the north wall, where it passed through an ash deposit 5 feet from right wall of cave and 30 inches from the floor of the cave at this point (see Plate X, Photo F). The artefacts obtained from this stratum consisted of potsherds, and stone implements in the form of notched scrapers, one produced on a concavo-convex flake.

Stratum No. 23 (between yards 4·2 to 12).—This was an extensive non-occupational layer of ochre (cave) sand, impregnated with ash between yards 4 and 7, of an average thickness of 3½ inches. The only artefacts encountered were a few potsherds, which had probably been trodden into it.

Stratum No. 24 (between yards 1·3 and 12).—This was one of the most extensive of the later occupational layers. It varied from an average thickness of 3·5 inches in the centre to as much as 12 inches at the north wall, where it dipped under some rock ledges and joined with stratum 12. Between pegs 4 and 6 at the north wall it merged into a consolidated sandy layer, so impregnated with calcium carbonate as to form a hard concretionary rock, which is seen in Plate X, Photo F, above upper line of string. It consisted chiefly of large shells of *Mytilus edulis*, with which were shells of *Haliotus natalensis*, several species of *Ostraea*, and various *Gasteropods*, admixed with fish remains, which in some portions, *e.g.* between yards 4 and 8, near the north wall, decidedly predominated. In addition to shells, other food remains found in this stratum consisted of portions of a crab carapace and bones of antelopes. Of vegetable remains, there were masses of leaves of the wild banana (*Strelitzia augusta*).

The artefacts encountered consisted of (*a*) a nearly complete large pot, found under a ledge of rock projecting from the north wall of the cave, and fragments of pottery, one of which had a pierced hole in it; (*b*) a bone point, a bone awl, and a portion of buffalo rib used in connection with pressure flaking of stone implements; and (*c*) a notched scraper and a few other stone implements.

The skeleton of a child, in embryonic posture, about 8 months old, was found on the ledge of concretionary rock opposite yard 2·5, amongst fish scales belonging to this stratum, and covered merely by 1 inch of dark soil.

Stratum No. 25 (between yards 1 to 13).—This was the most extensive non-occupational ochre (cave) sand layer. It covered the whole length and breadth of the cave, and was most extensively developed in the forward portion. Between yards 1 and 4 it was 2½ feet in thickness in the centre, diminishing to 10 inches at the north wall. Beyond this, *i.e.* between yards

5 and 13, it varied between 6 and 8 inches in thickness. In other words, it completely covered all the previous occupational strata to a depth of at least 6 inches. It was completely sterile, although a fireplace connected with the overlying shell layer dipped into it between yards 9 and 10.

Stratum No. 26 (between yards 6 and 10·7).—This consisted principally of shells, of which *Mytilus edulis* predominated, with a few limpets, *Patella rustica* and *P. sanguineum*, together with fish remains, which were extensive in places. It varied from 2 to 6 inches in thickness at the centre to as much as 18 inches at the sides, where it dipped down, following the curvature of the roof, to join stratum 16. Amongst the shell and fish remains, vegetable matter was encountered in the form of leaves of wild banana (*Strelitzia augusta*), and leaves and stems of a littoral dune bush (*Passerina ericoides*). The artefacts consisted of potsherds, bone points and awls, and stone implements, chiefly in the form of side-scrapers.

Stratum No. 27 (between yards 6 and 12).—This was a completely sterile layer of ochre (cave) sand, of average thickness of 3 to 6 inches. At yard 11 it was 14 inches in thickness, but vanished before yard 12.

Stratum No. 28 (between yards 9·5 and 13·5).—This was a layer of shells consisting chiefly of *Mytilus edulis*. It was from 2 to 6 inches in thickness at the centre, but on excavation proved to be 8 to 10 inches towards the north wall. Between yards 10·2 and 11·5 there was a well-defined fireplace. It contained potsherds, a bone awl, and some stone implements.

Stratum No. 29 (between yards 9·6 and 15).—This consisted of dark greyish-black friable soil with a few pebbles. It varied greatly in thickness, *i.e.* from 3 inches to a maximum of 12 inches, between yards 12 and 13. It contained mussel shells sparsely distributed, and some stone implements.

Stratum No. 30 (between yards 7 and 16).—This was the most recent layer. It consisted of two portions, viz. an underlying firm, compact, dark-coloured urine-impregnated earth, further consolidated with hairs of animals such as goats. It was from 1 to 2 inches in thickness.

Above this, *i.e.* the uppermost covering of the mound, was a loose layer of greyish dust from 1 to 18 inches in thickness, containing goat droppings and promiscuous litter.

Between yards 14 and 17, *i.e.* where the cave roof was only about 2 feet from the surface of the mound, this upper layer consisted entirely of ochre (cave) sand, upon which were a number of large, flat, sandstone rocks, and one boulder between yards 13 and 14.

From the previous description and the accompanying diagram and illustrations it is evident that the stratification was very irregular both longitudinally and transversely. This indicates, of course, that during many of the periods of occupation the whole of the cave was not com-

pletely and uniformly occupied, and that different portions of the cave were used for middens during successive occupations.

The accumulation of the ochre (cave) sand separating many of the occupational layers, which was derived from the roof and walls by the weathering action of the moist air upon it, must have been a slow process, and consequently where it extended through the whole area of the cave it indicates, according to its thickness, considerable intervals during which the cave was unoccupied.

Artefacts.

The distribution of the various types of artefacts is clearly shown in the distribution chart (Diagram III).

With one or two exceptions all the stone implements are of lydianite, which is obtainable about four or five miles north of the cave, across the river mouth.

Burins.—During a visit to the Durban Museum Mr. C. van Riet Lowe made a hurried inspection of the stone implements and recognised several burins amongst them (fig. 3, A, B, and C).

They are large implements, with trimmed concave edge at one end, from which a burin facet has been produced by a blow struck at right angles to it. In at least two instances each end of the implement has been similarly treated, and thus a double burin has been produced (fig. 3, A and C).

One from stratum 14 measures 8·5 by 7 by 3·1 cm., another from the same stratum measures 8·5 by 5·5 by 1·6 cm., a third, from stratum 16, measures 7·5 by 6 by 2 cm., and a fourth, from stratum 4, measures 8 by 6·5 by 2·5 cm.

Concavo-convex Scrapers (figs. 1 and 2, A and B).—One is in the form of a large side-scraper with curved cutting edge; it measures 15 by 6 by 1·5 cm. Another, from stratum 12, is in the form of an elongate ellipse, and measures 13 by 5·5 by 1 cm. A third, from stratum 2, is elongate, with a cutting edge along one slightly curved side. It measures 10 by 3 by 1 cm., but was originally longer. A fourth, from stratum 12, measures 9·5 by 5 by 1·1 cm. Its curved cutting edge exhibits that very fine trimming that has been produced by pressure-flaking. A fifth, from stratum 4, is 16 by 4·5 by 1·6 cm. It is of elongate, elliptical form, with finely trimmed cutting edge on the long side, opposite to the striking platform. There are many others.

Large Circular Scrapers.—Several examples of this type were obtained. One (fig. 2, C), measuring 7·2 by 5·1 by 0·8 cm., has an extremely fine edge, produced by pressure-flaking, and another of similar size (from stratum 28) is roughly trimmed.

Notched Scrapers or Spokeshaves (fig. 2, D, and fig. 4, B).—These are fairly numerous. Two are sickle-shaped, measuring 11 by 3·4 by 2·9 cm. and 11·5 by 4 by 1·4 cm. respectively. One from stratum 22 has been produced on a concavo-convex flake, it measures 9·5 by 4·5 by 1·3 cm.; two from stratum 16 measure respectively 10 by 6·5 by 3 cm. and 5·5 by 4·5 by 1·4 cm.; three from stratum 12 measure 6·5 by 5·2 by 1·6 cm., 11 by 4·4 by 1·3 cm., and 9·5 by 4·5 by 1·4 cm.; and one from stratum 4 measures 8·5 by 4·5 by 1·7 cm. A double-notched scraper of triangular form, from stratum 14, measures 8 by 6·5 by 1·6 cm.

Side-scrapers.—These were obtained in many varied forms in most of the strata. Some are very elongated, with cutting edge on one long side, the largest measuring 18 by 3·5 by 1·1 cm. (fig. 2, A). Many of them have that very finely trimmed cutting edge that has been produced by pressure-flaking; and bones were found, bearing numerous scars, that had evidently been used in connection with this pressure technique.

Pointed Side-scrapers.—In strata 12, 16, and 17 pointed implements of long triangular form, with cutting edges on both long sides, were obtained. The largest measures 13·2 by 6·6 by 2·1 cm.

Trimming Stones.—Implements of rectangular form, trimmed all round on one face, completely typical of the Lower Smithfield Culture, were found in strata 14 and 17 (fig. 5, A and B). The largest measures 12 by 7·5 by 3·1 cm.

Detaching Hammers.—Three detaching hammers, two from stratum 16, were obtained. The largest measures 10·3 cm. in diameter.

Stone Rings.—One complete, typical stone ring, measuring 12·5 cm. external and 4·5 cm. internal diameter, and 1·8 cm. in thickness; and the broken half of another, of similar size, were found in stratum 12. Both are stained with red ochre, suggesting a ceremonial or ornamental purpose. The small internal diameter would preclude their use as arm-rings, in the manner of the Tuareg at the present day (*vide* F. Rennell Rodd, People of the Veil, p. 285).

Grindstone.—A stone slab, roughly circular in shape, 16 cm. in diameter and 4·5 cm. thick, was found. The upper surface is worn smooth with use, and it is discoloured with red ochre, indicating that it was used for grinding this pigment.

Pounders and Grinders.—Three flat, water-worn pebbles, approximately 6 cm. in diameter and 2·5 cm. thick, were found, one being obtained from stratum 4. In each, one edge bears scars where it has been used for pounding, and the opposite edge is worn flat and smooth where it has been used for grinding. All are stained with ochre, and several lumps of red ochre were obtained.

Re-use of Earlier Implements.—Two implements are particularly worthy

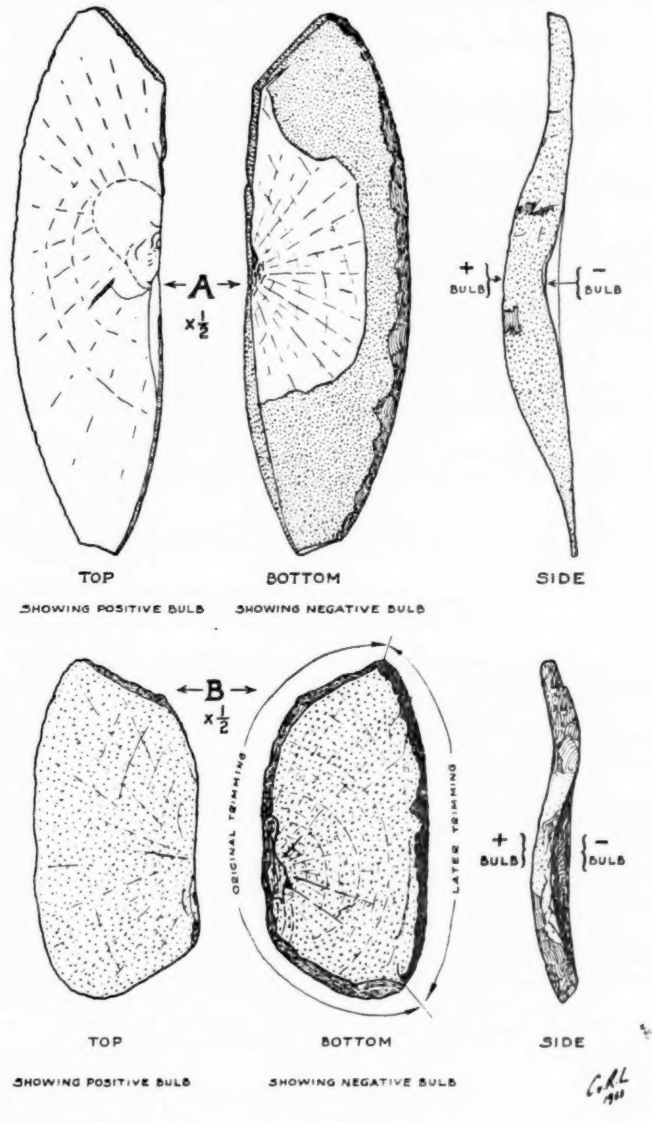

A
x 1/2
+ BULB
− BULB
TOP
SHOWING POSITIVE BULB
BOTTOM
SHOWING NEGATIVE BULB
SIDE
B
x 1/2
ORIGINAL TRIMMING
LATER TRIMMING
+ BULB
− BULB
TOP
SHOWING POSITIVE BULB
BOTTOM
SHOWING NEGATIVE BULB
SIDE

FIGURE: 1.

of note. One is a long flake (fig. 3, D), 10 by 4 by 0·8 cm., with fluting marks on the upper side and evidence of trimming on one long edge, reminiscent of the Mossel Bay culture. It has a well-developed rough patina of brownish colour. On one long side it has been completely retrimmed, and as this later trimming shows no patina it contrasts very strongly with the patinated surface of the implement.

The other is a concavo-convex implement (fig. 1, B), roughly elliptical in form, 10 by 5 by 0·8 cm., trimmed at the ends. It is covered with the light-grey patina that is produced on lydianite in water. It has been trimmed along one edge after patination, and there is a great contrast in colour between the patinated surface and the unpatinated trimming. Nevertheless, the form of the implement in its original state is a common type in the culture as a whole, as represented at Umgazana; and this suggests that the concavo-convex scraper is a type of implement that persisted over a lengthy period.

Bone Implements.

Points.—Bone points of two forms were obtained in strata 4, 12, 14, 16, 17, 24, and 26. Both are circular in section, from 4 to 8 mm. in diameter, and measure up to 12 cm. in length. Most of them are excellently finished and highly polished, and two have a single engraved line in the form of a ring encircling them. One form is pointed at both ends, while the other is truncated at one end (Plate XI, Photo G, 1–3).

Awls (Plate XI, Photo G, 7).—In strata 4, 12, 16, and 24 bone awls were obtained. They are fashioned from metatarsal bones of antelopes. A transverse cut, half-way through, was made a short distance from one end, and half the thickness of the bone cut away from this to the other end; the edges of this cut portion were then trimmed and ground to a point. They measure from 8 to 19 cm. in length.

Large Needle-like Implements (Plate XI, Photo G, 5).—These are long, flat pieces of bone with a blunt point at one end and a hole at the other. They are mostly about 14 cm. in length, although one measures as much as 16·8 cm., and 1·2 cm. in width, and about 3 mm. thick. One side is flat and the other rounded. They were obtained from strata 4, 12, 14, and 15.

The question arises: To what purpose were these implements applied? Various purposes have suggested themselves. They may have been used for separating the skin from animals killed in the chase, and the eye-like hole have served to attach them to the person of the owner. In this case, however, the edge would have shown more polish with use, whereas it is the blunt point that shows most polish. Another suggestion is that they

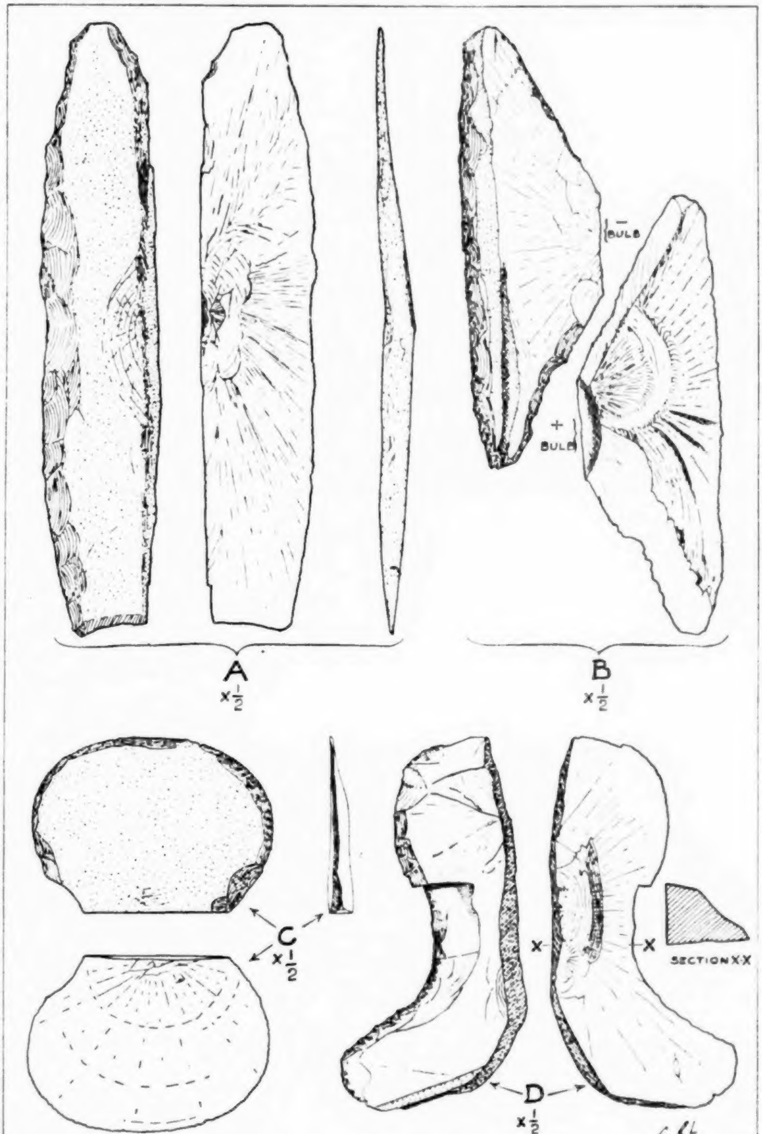


FIGURE: 2

served as perspiration scrapers in similar manner to those in present use by the Bantu. Again, to account for the extensive capture of fish for food, and the capture of fishes up to 18 lb. in weight as remains in the occupational layers indicated, they may have served as net-making implements. But although a diligent look-out was kept for any remains of nets, not a vestige was found. We are inclined to the opinion that they were used in conjunction with the awls for the sewing of skins for clothing, the holes being previously pierced by the awls.

Needle-like Implement of another Type (Plate XI, Photo G, 4).—In stratum 14 a bone implement was found which bears a striking resemblance to a modern steel packing-needle, except that the eye is absent; but as this end has been broken off, it is possible that it originally bore an eye. It measures 12·8 cm. in length.

Spatula (Plate XI, Photo G, 6).—A single implement of spatula form was obtained. It measures 14·7 by 1·8 cm., and is of uniform thickness, viz. 2 mm. Three deep V-shaped indentations have been cut on each side, and its surface bears numerous deep scratches.

Bone Platforms for Pressure-flaking.—Mr. van Riet Lowe drew our attention to several pieces of bone that bear scars where they have been used in removing fine chips from the edges of implements by means of pressure. The largest, from stratum 14, appears to be a portion of the rib of a buffalo. It measures 19·3 by 4·8 cm.

Nacre Disc.—A single nacre disc, neatly shaped to a circular form from an oyster-shell, and measuring 5·5 cm. in diameter, was obtained from stratum 12.

Wooden Pegs.—A pointed wooden peg was obtained from stratum 4. It is a portion of a branch of a tree, and measures 16 cm. in length and 3 cm. in diameter. One end has been very neatly sharpened; the facets are slightly concave, and their edges are so sharp that they appear to have been cut with a very sharp knife having a flexible steel blade. Similar pegs were found in strata 12 and 14, and one of us succeeded in fashioning a peg with similar facets by means of a stone implement recovered from the deposit.

Pottery.

Sherds of coarse black pottery, containing grit, were found in the upper occupational layers, viz. 14, 16, 18, 24, and 26, but did not occur in strata below No. 14. The forms represented are spherical, with round, or slightly flat bases. The only ornamentation is around the rim. It consists of simple forms impressed before baking. There are no lugs on any of the sherds, but one has a conical hole that has evidently been bored into it after the pot was baked.

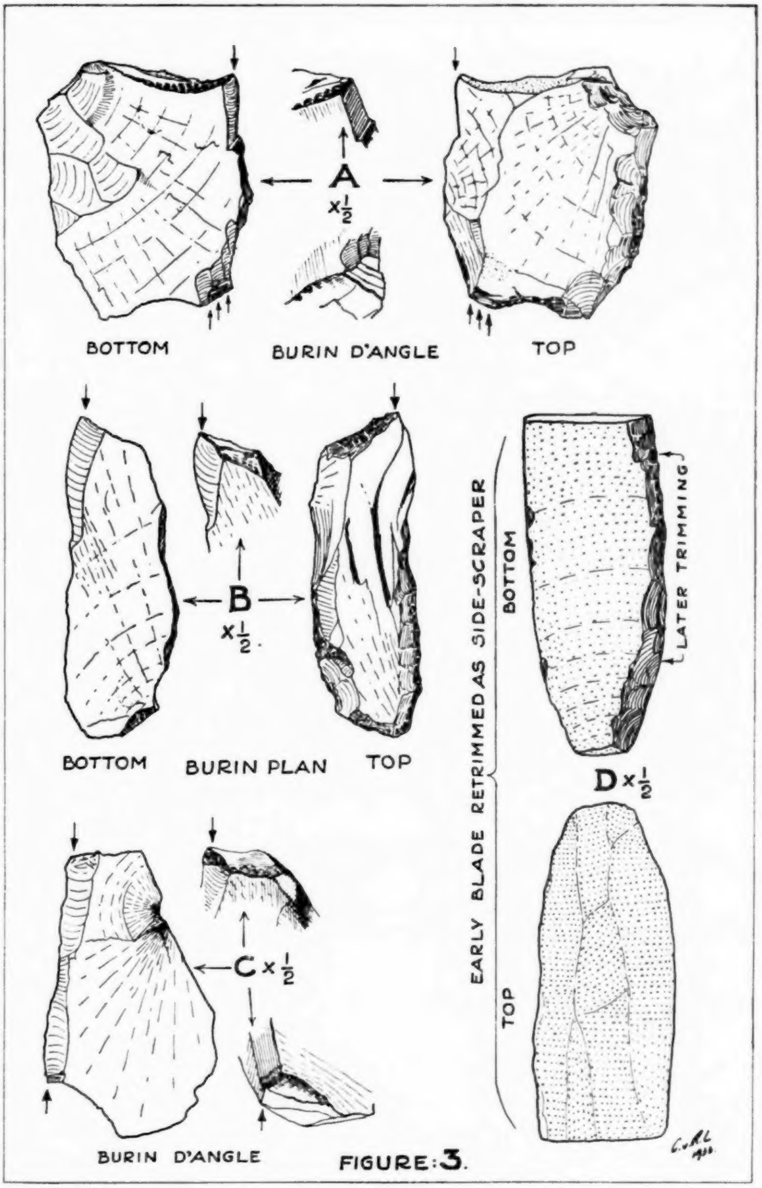

A
x½
BOTTOM
BURIN D'ANGLE
TOP
B
x½
BOTTOM
BURIN PLAN
TOP
C x ½
BURIN D'ANGLE
EARLY BLADE RETRIMMED AS SIDE-SCRAPER
BOTTOM
TOP
LATER TRIMMING
D x ½

FIGURE: 3.

Skeletal Material.

Apart from the disintegrated human remains encountered in stratum 12, the only skeletal material recovered from the deposits was the skeleton of a very young child, too young to denote its racial characteristics, found in an embryonic posture in a layer of fish scales and bones (stratum 24) on a ledge of consolidated sand at the right wall, overlaid by a surface deposit of manure-impregnated dark soil 1 inch thick.

A disturbed area in the deposits in the form of a basin that was revealed in the right wall of the trench, between yards 16 and 17, suggested that a burial had taken place at this spot. But although a diligent search was made during careful excavation of this area, no skeletal material was found.

Conclusions.

It should be noted that no duck-bill end-scrapers, stone-borers, bored stones, grooved stones, paintings, engravings, ostrich egg-shell beads, or borers were found.

Pottery was found in the later occupational layers, from stratum 14 upwards, bone implements from stratum 4 upwards, but the stone implements, which were more numerous than any other artefacts obtained, and occurred in all the occupational strata, showed a remarkable similarity of type and technique throughout.

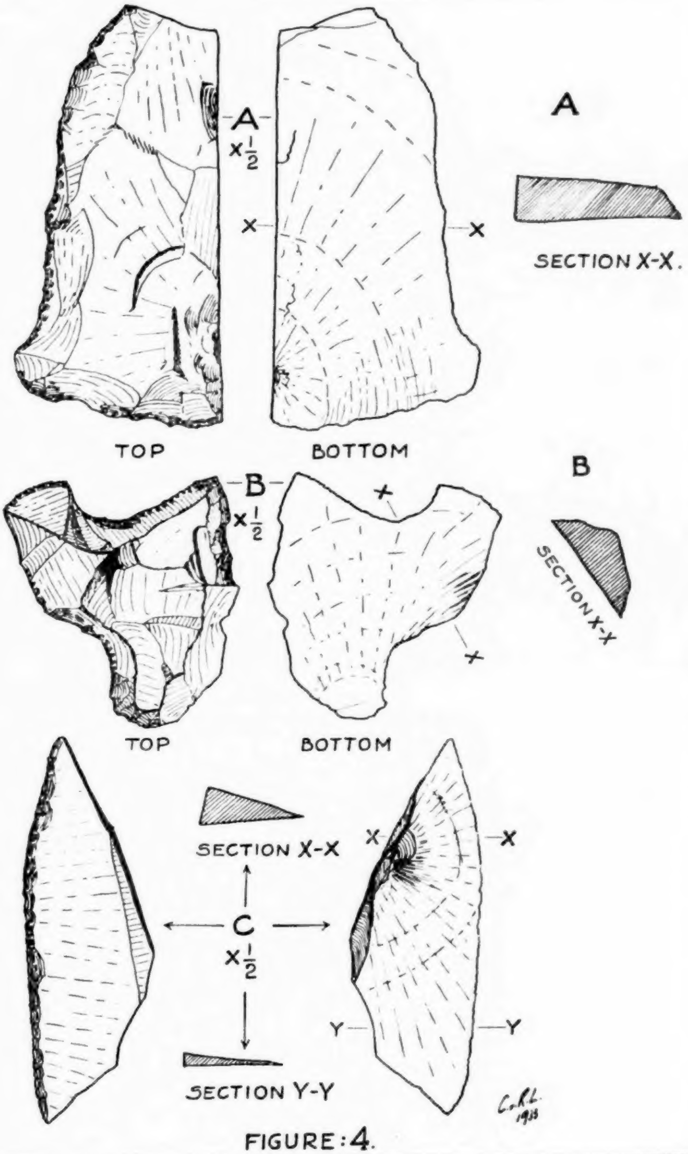
There can be no doubt that the congeries is assignable to the Smithfield Culture, although burins have not been previously recognised from it.

The presence of concavo-convex scrapers and large circular scrapers indicates the early division of the Smithfield Culture, Smithfield A, of Mr. van Riet Lowe; and as this is the first time that material of this division has been found in a cave deposit, it is not surprising that it shows a variation from the typical congeries of this division from open sites.

Notched scrapers and stone rings have hitherto only been known from later divisions; and pottery had not hitherto been found definitely associated with material belonging to Smithfield A.

Most important, however, is the fact that bone implements have for the first time been found in association with early Smithfield material, and it is very remarkable that the numerous bone implements discovered indicate a bone industry more highly developed than those of the later Smithfield divisions and the Wilton Culture.

For these reasons we are of opinion that a variation of the A division of the Smithfield Culture is represented by the material here described, and we propose that it should be distinguished by the term "Umgazana Variation of Smithfield A."


A
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TOP
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B
SECTION X-X
TOP
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SECTION X-X
X
X
C
x 1/2
Y
Y
SECTION Y-Y

FIGURE: 4.

It appears to bear little affinity to Mr. A. J. H. Goodwin's "Variation N of the Smithfield Culture," characterised by strangled end-scrapers, a variety of notched scrapers, and including duck-bill and other end-scrapers (*vide* Trans. Roy. Soc. S. Afr., vol. xix, p. 7, 1930).

Congeries of Umgazana Variation of Smithfield "A" Culture.

1. Concavo-convex scrapers.
2. Circular scrapers.
3. Notched scrapers.
4. Burins.
5. Side-scrapers.
6. Trimming stones and detaching hammers.
7. Stone rings.
8. Pounders and grinders.
9. Bone points.
10. ,, awls.
11. ,, needle-like implements.
12. Pointed wooden pegs.
13. Pottery.
14. Nacre disc.

Acknowledgments.

We wish to express our sincere thanks to Mr. A. J. H. Goodwin and Mr. C. van Riet Lowe for the valuable advice that they have given and the encouraging interest they have shown during the preparation of this paper, and to the latter for describing and making the drawings of stone implements for illustrations; to the Rector and the Professor of Geography of the University of Pretoria for facilities accorded in the preparation of the diagram of the section of the deposits; and to Mr. and Mrs. McDonald of the Umgazana Trading Station for their generous hospitality and assistance during our visit to the cave.

Note.—After a brief examination of the material obtained from the site, and reading the manuscript of this paper, Mr. C. van Riet Lowe favoured us with the following remarks:—

"My interpretation of this peculiar and most interesting variation of the Smithfield Culture is that, from the evidence available, it would seem we are at, or near, the end of a migratory arm of Lower Smithfield folk who, while originally practising the Lower Smithfield Culture as it is known in the upland plains of the Free State and North-Eastern Cape, introduced or had thrust upon them certain changes during the migration from the upland plains to the coast. Starting as hunters on the plains, they ultimately became a fisher folk, and their material culture metamorphosed in accordance with their needs and

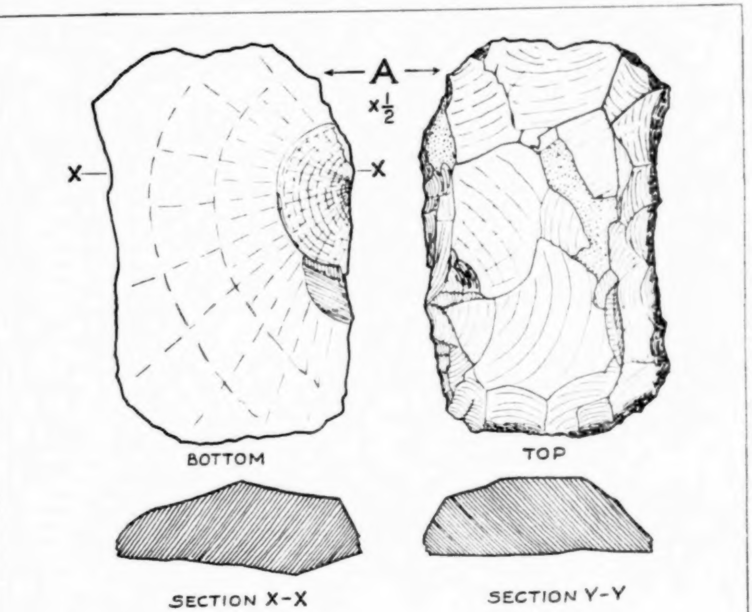


FIGURE: 5.

pursuits. For example, the remains in this case show that while the earliest occupants continued to exist largely on a hunter's diet, the later occupants lived almost entirely on fish. The early appearance of the plain angle burin and its associated bone technique (unknown in the Lower Smithfield of the Free State where the culture was practised by a purely hunting folk) is indicative of the first marked change. Typical Lower Smithfield tools continue (most notably the specialised concavo-convex scrapers which exist here in great abundance), but new forms appear and certain old forms disappear. The burin, for example, is not known in the Lower Smithfield of the Free State, because the folk who practised this culture are not known to have specialised in bone tools, whereas in the movement that led to this Umgazana variation of the parent Smithfield bone tools obviously supplied a specific need, and the burin was invented, or *vice versa*.

"I cannot escape the conviction that we are in the presence of a most interesting cultural metamorphosis set in motion and stimulated by a gradual change of diet and new environmental conditions.

"Instead of the evolutionary process experienced by the hunters of the upland plains and those who left them for the mountains, this migratory arm of Lower Smithfield folk experienced new urges and needs as they moved to the coast. In the Orange River Basin the movement was from the plains to the mountains, and the changes were Lower (or A) to Middle (or B) to Upper (or C) Smithfield. In the movement that led to the occupation of the Umgazana Cave the change was from the plains to the coast, and the material culture metamorphosed from the Lower (or A) to this Umgazana variation of the parent Smithfield Culture."

Mr. van Riet Lowe subsequently stated: "It has been found that similar though much smaller assemblages occur at other places near Port St. Johns, viz. Mt. Sullivan and the Zig-zig Cave. This indicates the possibility that this variation was practised over a wider area than appears to be the case at the moment; and time may reveal that a definite culture, based upon this variation, existed over an extensive area."

DESCRIPTION OF FIGURED IMPLEMENTS.

All the implements illustrated are of indurated shale. The figures are half actual size.

FIG. 1, A. Typical Lower Smithfield concavo-convex side-scraper or flaying tool. Stippled surface shows rock-crust.

B. Typical Lower Smithfield retrimmed concavo-convex scraper. Marked difference of patina between original secondary trimming and retrimmed edge. Stippling shows original, weathered, cleavage faces.

FIG. 2, A. Unusually long and slender side-scraper, poor negative, but marked positive, bulb.

B. Triangular form of concavo-convex, typical of Lower Smithfield.

C. Typical Lower Smithfield circular scraper, showing positive bulb only. Rock-crust stippled.

D. Typical hollow scraper or "spokeshave."

FIG. 3, A. Much worked double-ended *burin d'angle*, showing hollow secondary trimming immediately adjacent to the burin blow.

B. *Burin-plan* and side-scraper combined.

C. Double-ended *burin d'angle*.

D. Broken Mossel Bay type blade, retrimmed as a side-scraper.

FIG. 4, A. Typical heavy Lower Smithfield side- and end-scraper, probably also used as fabricator (trimming stone).

B. Double hollow-scraper or "spokeshave."

C. Side-scraper of triangular type, positive bulb only.

FIG. 5, A and B. Typical Lower Smithfield trimming stones on flakes, with characteristic step-flaking along working edges.

EXPLANATION OF DIAGRAMS.

Diagram I. Plan of cave, with trial trench indicated by dotted lines.

,, II. Section of cave and deposits as seen on right wall of trial trench, along line AB of plan (Diagram I). The figures indicate yards horizontally and feet vertically.

,, III. Chart showing distribution of artefacts and food.

EXPLANATION OF PHOTOGRAPHS.

Plate VIII, Photo A. Umgazana Cave, in sandstone cliff, covered with wild banana (*Strelitzia augusta*).

,, B. Section through deposit at inner end of right wall of trial trench.

Plate IX, Photo C. Section through deposit at outer end of right wall of trial trench.

,, D. Deposits in section, showing on left, horizontal yard-pegs and vertical foot-pegs, for making Diagram II.

Plate X, Photo E. Excavation of deposits, layer by layer.

,, F. Transverse section of deposits near yard-peg 5.

Plate XI, Photo G. Bone implements—1, 2, and 3, points; 4, "packing-needle"; 5, blunt needle-like implement; 6, spatula; 7, awl.

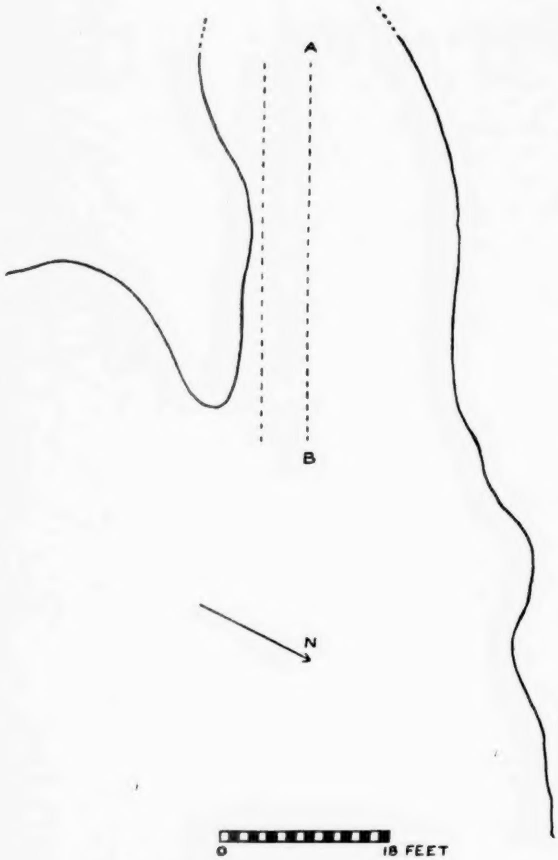
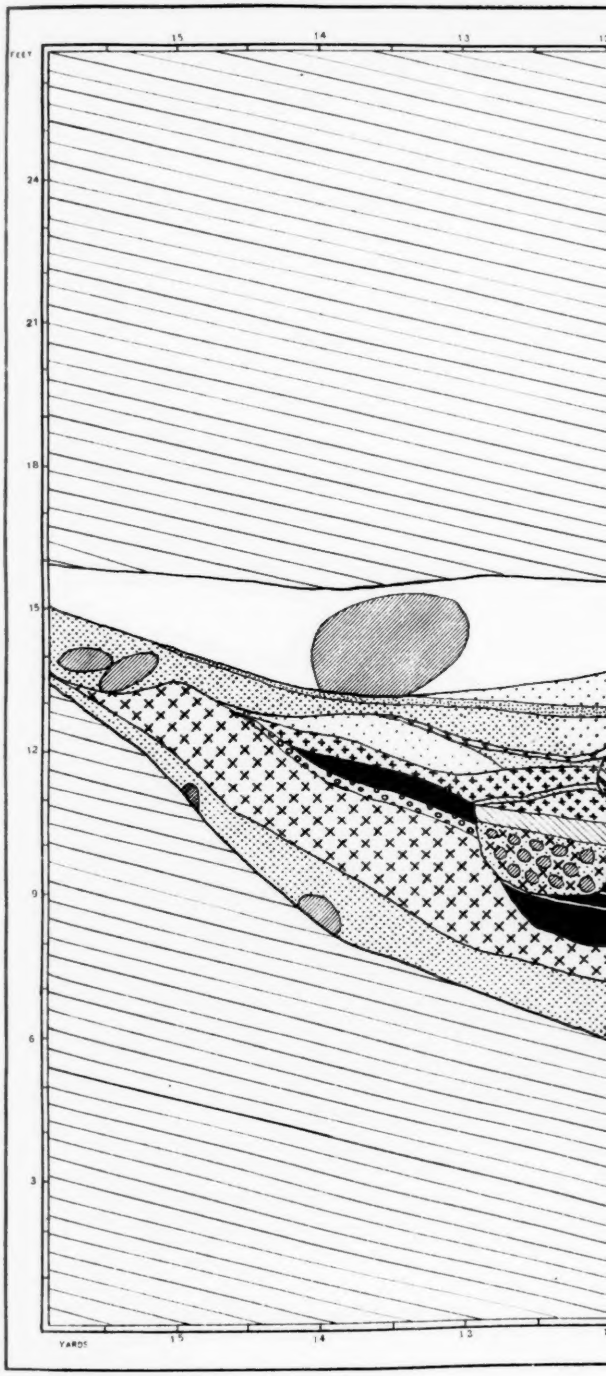


DIAGRAM I.—Plan of cave.



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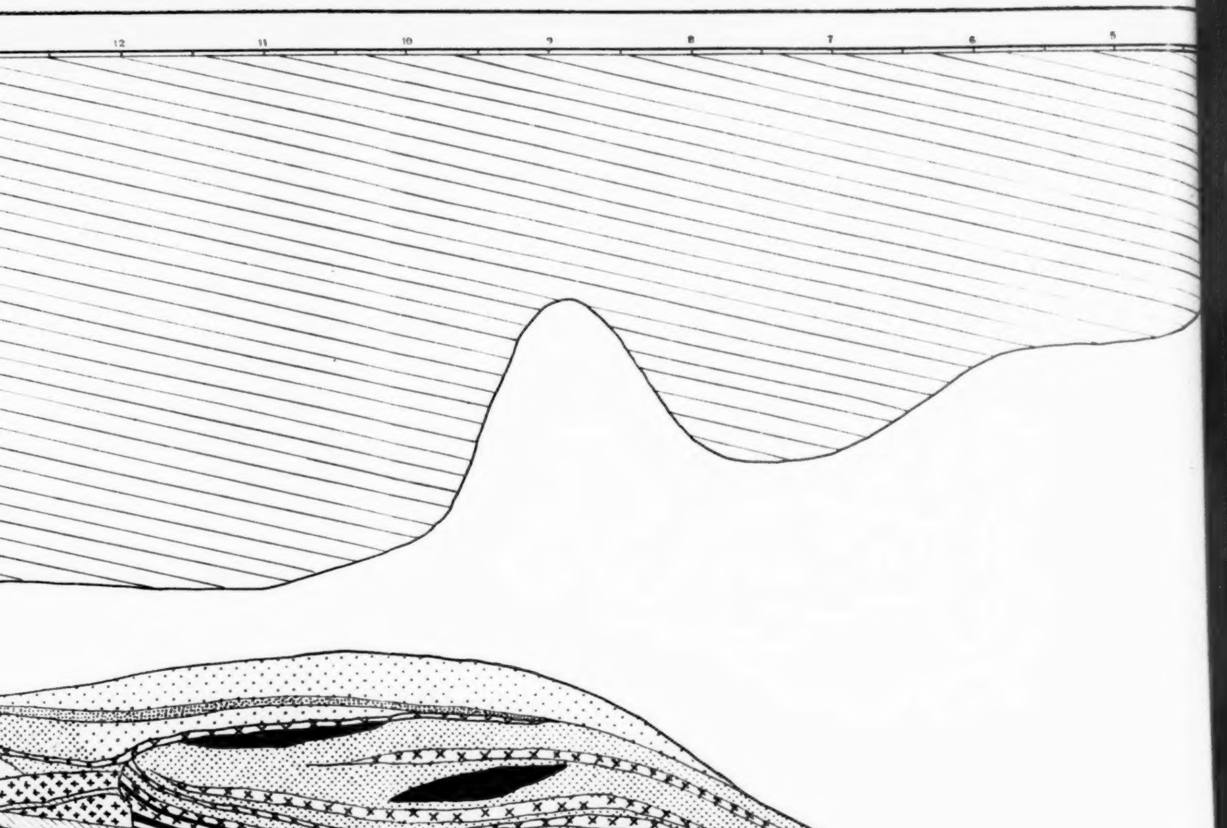


DIAGRAM II.—Umgazana Cave, Pondoland (1933).

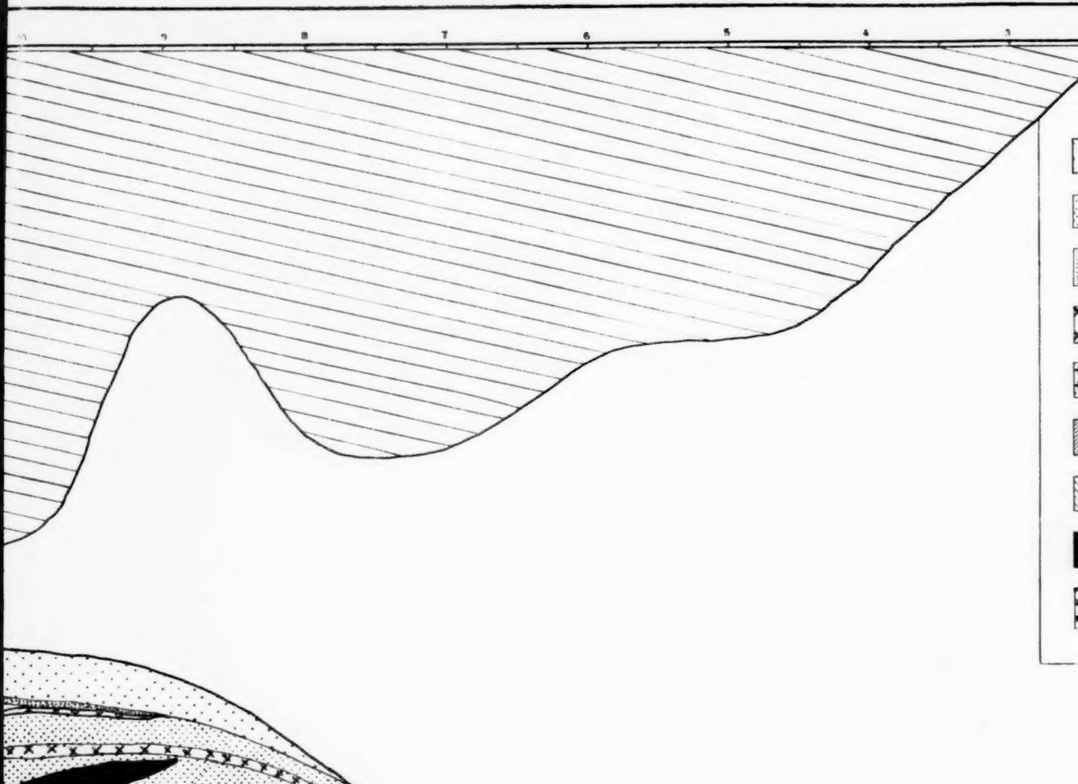
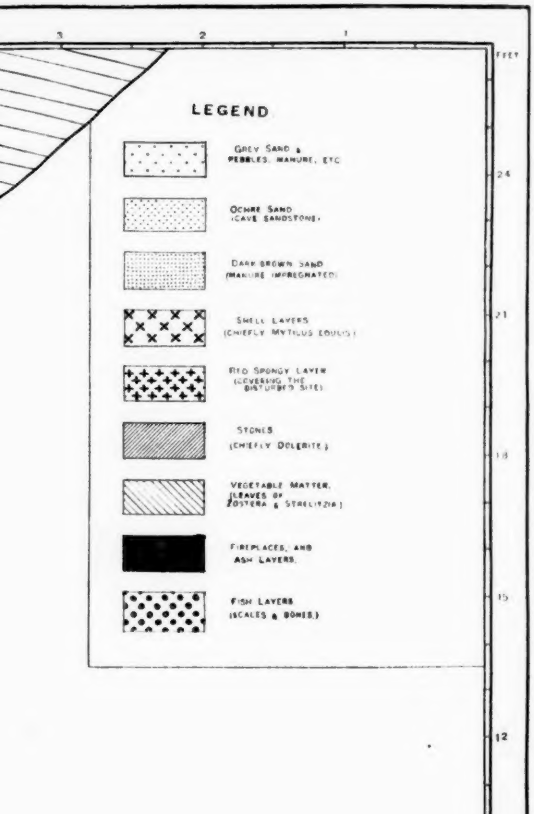


DIAGRAM II.—Umgazana Cave, Pondoland (1933).

[*To face p. 268.*


LEGEND
Grey Sand & Pebbles, Manure, etc
Ochre Sand (Cave Sandstone)
Dark brown Sand (Manure Impregnated)
Shell Layers (Chiefly Mytilus edulis)
Red Spongy Layer (Covering the disturbed site)
Stones (Chiefly Dolerite)
Vegetable Matter, (Leaves of Zostera & Strelitzia)
Fireplaces, and Ash Layers.
Fish Layers (Scales & Bones)
Feet
24
21
18
15
12
9
6
3
3
2
1

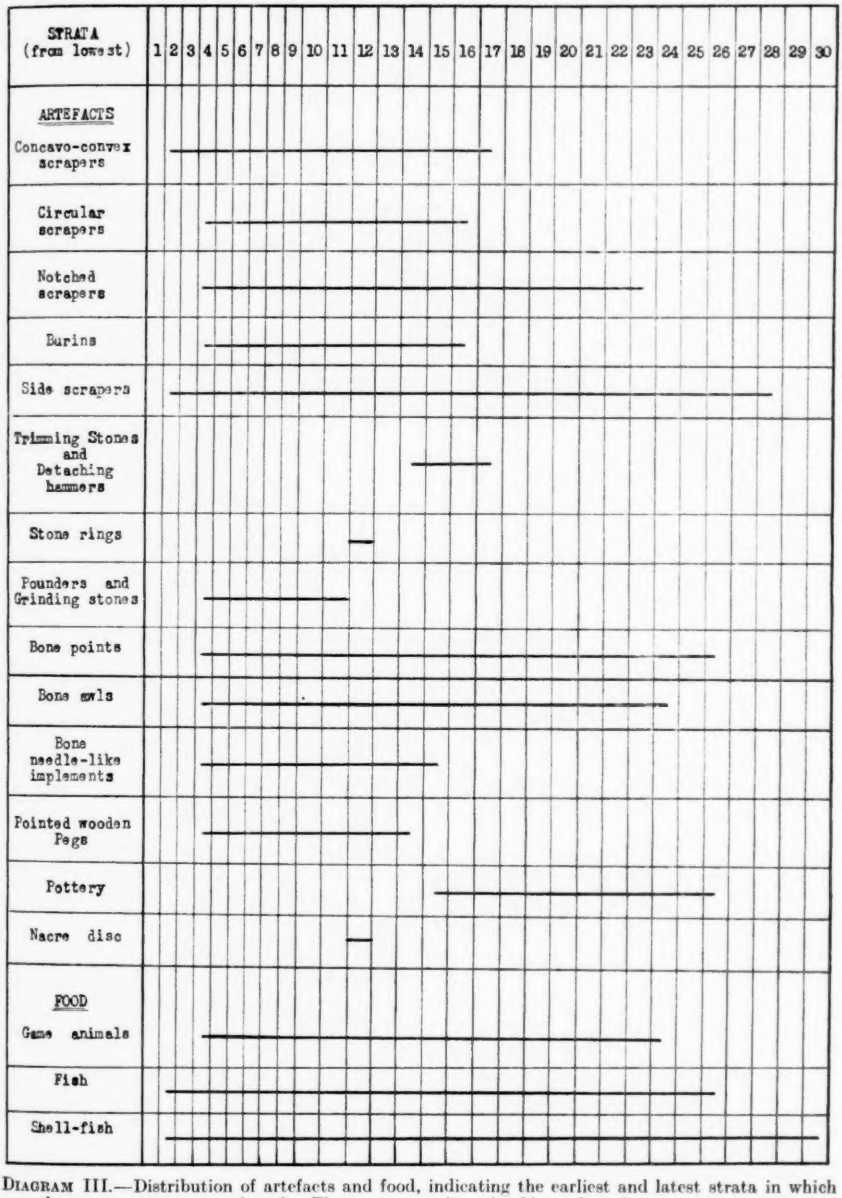


DIAGRAM III.—Distribution of artefacts and food, indicating the earliest and latest strata in which the various types were found. The continuous line should not be taken as an indication that the particular type was found in *all* the intermediate strata.

Photo A.—Umgazana Cave (x) in sandstone cliff.

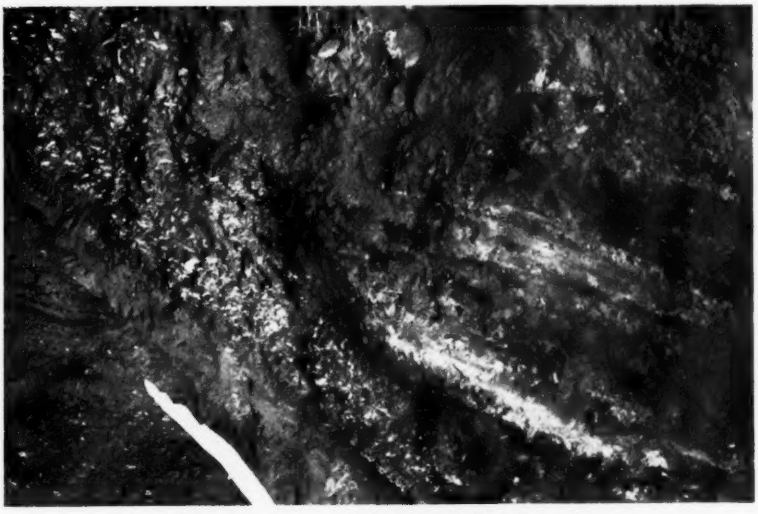


Photo B.—Inner end of right wall of trial trench.

Chubb, Burnham King, and Mogg. *Neill & Co., Ltd.*

PHOTO C.—Outer end of right wall of trial trench.

PHOTO D.—Showing use of pegs for making Diagram II.

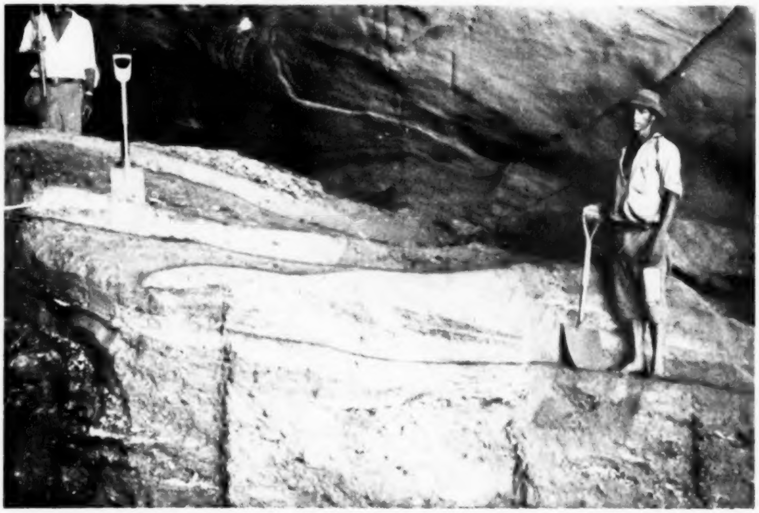


PHOTO E.—The deposits in course of removal, layer by layer.

PHOTO F.—Transverse section of deposits near yard-peg 5.

1 2 3 4 5 6 7

Photo G. Bone implements. About two-thirds actual size.

Chubb, Burnham King, and Mogg. Neill & Co., Ltd.

NEOLITHIC STONE IMPLEMENTS FOUND AT REGINA, WESTERN TRANSVAAL.

By MARGARET ORFORD, Department of Anatomy, University of the Witwatersrand, Johannesburg.

(Communicated by R. A. DART.)

(With Plate XII and two Text-figures.)

(Read March 21, 1934. Revised MS. received June 15, 1934.)

1. INTRODUCTION.

Two polished Neolithic spearheads have been presented to this Department. Unfortunately very little is known about their history. A farmer found them along with a similar spearhead and two polished stone rings near Regina, while he was sinking a well. My uncle, Mr. T. Leask, the donor, wrote the following:—

"I have even forgotten the name of the Boer who gave them to me, and am rather under the impression that he is dead. He certainly thought little of his find—as did I at the time. . . . *They certainly are not fakes, as there was no incentive to make them!*"

Apart from being certain of their genuineness, we know nothing more than that they were found about 12 feet from the surface during the sinking of a well in the Vaal watershed in the vicinity of Regina, Western Transvaal.

2. DESCRIPTION.

These two stone implements of Neolithic type have been examined by Professor R. B. Young, head of the Department of Geology in this University. He reports that the stone of which they are made is a mixture of soapstone and quartzite. They are both dagger-like implements. The proximal ends are so shaped as to suggest that they were originally hafted.

So comfortably do they fit the hand, however, and so effective would they have been when used in this manner, they could have been serviceable without hafting.

Specimen I.—The larger of the two implements (Plate XII) is the more perfect of the two, although the tip has been broken off. It is symmetrically balanced, and the whole surface is smoothly polished.

The measurements of the implement in its present state are:

Maximum length	20 cm.
Maximum breadth	6·3 ,,
Breadth at constriction	2·9 ,,
Breadth of superior end	2 ,,

When the contour of the lateral margins are prolonged distally until they meet, a hypothetical maximum length of 20·9 cm. is obtained.

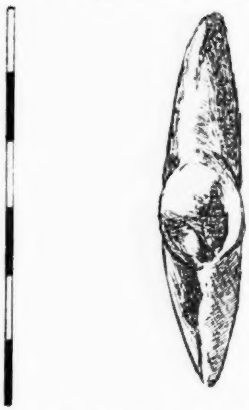


Fig. 1.—Specimen I, viewed end-on from the handle.

The implement is leaf-shaped. The two convex faces of the blade meet on either side in a well-defined edge at an angle of about 25°. The two surfaces are equally convex and perfectly symmetrical.

The two edges converge superiorly and inferiorly as may be seen in Plate XII. At a distance of 4·5 cm. from the proximal end they change their direction, and, instead of being curved, are continued in slightly converging straight lines.

The proximal end is relatively thick. When viewed end-on it presents the appearance of a fairly regular hexagon, half as broad as it is long. The boundaries of the hexagon are smoothly rounded, the polishing being continued over the proximal end.

From the direction of the superficial striae, the polishing was done in two directions at right angles to one another. The preliminary polishing appears to have been done transversely, the final polishing being in a longitudinal direction., Most of the marks of the polishing are so fine that they may be seen only when viewed obliquely in a strong light or under a binocular microscope.

On one surface are larger scars—two transversely in the proximal half of the body, and three longitudinally in the distal half. These appear fairly recent, and may well be the result of scratching during or since the discovery.

The longitudinal marks of the polishing are much more marked on one face than on the other.

Specimen II.—The second implement (Plate XII) is considerably smaller than the first. Its measurements are:

Maximum length	14 cm.
Maximum breadth	4·2 ,,
Breadth at constriction	2·5 ,,
Breadth of proximal end	3·3 ,,

The blade consists of two convex faces—one decidedly more convex than the other, meeting at well-marked edges. It is lanceolate in shape, and has an almost propeller-like twist in its shaft.

Fig. 2.—Specimen II, viewed end-on from the apex of the blade.

Both faces are smoothly polished, the polishing here having apparently been carried out in three directions—longitudinally, transversely, and obliquely.

The blade is fairly symmetrical and ends in a rounded tip. Between the blade and the proximal end is the constriction previously discussed. The portion above the constriction is polished, but less carefully than the blade. This part is rough and unsymmetrical, one of its borders rising higher than the other. It shows again two convex surfaces, one being more convex than the other in accordance with the difference in convexities of the blade. These surfaces, however, do not meet in a sharp edge, but are smoothly rounded into one another.

From the verbal description of the stone rings which I received it seems that they were 3 inches in diameter, under an inch in thickness, and composed of the same material.

3. Discussion.

The history of the discovery of these Neolithic stone implements is minimal. All we know is that they were reported as found at a depth of 12 feet.

It may be theorised that such perfect specimens could not have been carelessly lost, but that they were deliberately placed in the ground as part of a burial ceremony.

We know nothing of the arrangement of strata in which the tools were found. It is impossible, therefore, to assign to them even an approximate age. It is not extravagant, however, that polished stone objects should be found in Southern Africa at such a depth as that above cited. Dart (1929) describes a polished conical stone object from Rustenburg at a depth of 17 feet, and also perforated stones and polished axes showing Neolithic influence from Mumbwa (1931) at a depth of 5 feet. Excavations at Broken Hill revealed a perforated specimen 5 feet below the present ground level.

(i) *General.*—As recently as 1929, as may be gathered from the following statement by Goodwin, the position relative to Neolithic influences in South African cultures was very uncertain. He said:

"Whether Neolithic elements constitute a normal part of our prehistory or are merely sports thrown off in the evolution of local industries is a question which must remain unanswered, until such time as our prehistory is a known science, rather than an inchoate feeling into the past."

Polished stone rings are an important diagnostic feature of the Smithfield industry, and we are therefore justified in describing the polished stone rings found in association with these spearheads as an outcome of that culture.

This cache of rings and soapstone Neolithic daggers forms one of the most complete evidences of true Neolithic art in stone which the country has yet presented. At the same time the simultaneous discovery of polished Neolithic stone daggers and genuine polished stone rings of Smithfield type in this cache forms an obvious connecting link between the Smithfield industry and the Neolithic culture. Such a connection has been suggested before by the intrinsic features of the Smithfield industry, such as perforated stones, grindstones, smooth stone palettes and mullers, but the present instance is the most important affirmation of Burkitt's statement (South Africa's Past in Stone and Paint) that:

"Although there is no evidence that Smithfield man practised agriculture or the domestication of animals, the presence of pestles and mortars, or, more properly speaking, querns, together with pottery, rather argues that the culture should be assigned to a perhaps ill-developed, but definitely Neolithic, civilisation."

This discovery, then, not only confirms but enlarges the scope of Burkitt's statement. There are widespread evidences of Neolithic influence in Southern Africa, and such evidences are continually being increased. More and more is the conviction dawning that not only was there a Neolithic culture, but that this culture was highly developed. The elements described in this paper are a definite confirmation of this conception.

The majority of the Neolithic specimens previously described have consisted of edge-polished river pebbles chosen for their shape, but not otherwise worked. Hewitt (1929) described types of Neolithic axe from Vaalkrants, near Grahamstown, and Picquetburg. Drennan (1930) reported a ground stone axe prepared for hafting from a rock-shelter at Witsands on the Atlantic side of the Cape Peninsula. Implements showing Neolithic influence are described by Dart from Rustenburg and Mumbwa.

Goodwin (1930) describes ground stone axes from Rhodesia and the Transvaal. One of the latter is of a special character, in that it is the

only perforated stone axe yet found in South Africa. A further point of interest with regard to this implement is that it was found at Potchefstroom, which is only 40 miles distant from Regina. Yet more interesting is the fact that this axe is completely polished, and exhibits almost perfect symmetry. In these features this specimen compares favourably with those forming the subject of this discussion. The fact that the three most perfect examples of Neolithic influence yet described in South Africa have been discovered in the Western Transvaal may prove of significance. It is possible that Neolithic culture was particularly displayed in this area, and extended its influence in South African stone cultures from that region.

These specimens from Regina are unmistakable evidence of the fact that the Neolithic influences suggested by the elements mentioned above are part of a definite South African Neolithic culture. We may then assume that polished perforated stones, conical phallic objects, and pestles and mortars found in South Africa are the direct outcome of that influence.

(ii) *The Neolithic Age and Metal Gathering.*—The metallic nature of certain symbols, such as the axe depicted in rock engravings, has led to certain of these engravings being associated with the metal gatherers. Dart (1931) said:

> "The importance of the Lydenburg engravings lies in the fact that they are meaningless unless we assume them to have been made by metal-gatherers of the late Neolithic or early Bronze Age."

This connection has been assumed because of the impossibility of producing deep incisions on the rock with other than metal instruments. In many cases the chisel marks are still visible in the engravings.

Polished stone axes and perforated round stones found in the furnace stratum at Mumbwa furnish a further connecting link between Neolithic man and the age of metal gathering.

Many antiquarians maintain that all polished stone weapons are ancestrally copies of metal objects. If perforated stone axes were copied from metallic models, then Goodwin's example from Potchefstroom could be regarded as further evidence that South African Neolithic culture owed its origin to the metal gatherers. So symmetrical and blade-like are the Regina implements that we may well look upon them as metal copies.

Weapon blades of that size in iron in this country are characterised by the possession of a strong midrib. These specimens have no midrib, and if they are copies of metallic models these models must have belonged to an earlier metal industry; that is, to the Copper or Bronze Age. Dart (Nature, 1929) pointed out that bronze was unquestionably manufactured during prehistoric times in the Transvaal, and that there was probably no separation in time of the Neolithic and bronze phases in South Africa.

Assuming this to be the case, the possibility of these implements being copies of bronze objects cannot be denied.

(iii) *Correlation of the Specimens with other South African Industries.*—As has already been pointed out, the association of Neolithic daggers and Smithfield stone rings forms a definite connecting link between these two industries. Dart (1931) stated that:

"the Smithfield and Wilton industries, which display these Neolithic practices, are no other than the bastard product of Palaeolithic and Neolithic fusions."

Smithfield evidences are widespread in Southern Africa. Neolithic man presumably came in from the north, and spread his type of culture among the pre-existing population, who failed to master his art completely. They absorbed what he brought into what they already had. Pure Neolithic elements are thus rare, but these typical specimens are definite evidence that Neolithic man did leave his mark on South African stone industries.

With regard to the material: soapstone is not known to have been used during the Early and Middle Stone Ages as a material for the manufacture of implements. Its softness would fail to render tools made from it serviceable. The Late Stone Age seems to afford the first evidence of its use in the manufacture of tools, ornaments, and utensils. It is the Smithfield culture that first includes perforated stones and rings made of soapstone, a further and material corroboration of Burkitt's statement correlating the Neolithic and Smithfield industries. Further, crucibles, phalli, bowls, and monoliths surmounted by figures of birds and crocodiles in soapstone are characteristic of the Zimbabwe culture. We have here, then, a most significant similarity in choice of material by Smithfield man, Neolithic man, and the makers of the Rhodesian gold mines and ruins. It would, indeed, be extraordinary if this similarity in material did not symbolise a correlation between the Rhodesian ancient mining culture and the Late Stone Age cultures of South Africa.

4. Summary.

The two specimens from the Western Transvaal described in this paper afford some evidence of a definite Neolithic culture in South Africa. The perfect technique and finish which they exhibit form convincing proof of this statement. Previous discoveries showing Neolithic influence from South Africa in general and the Transvaal in particular are thus corroborated and extended. The association of Smithfield rings and Neolithic daggers in this cache proves the existence of a definite link between these industries, a connection which has previously been suggested by Burkitt,

Dart, and Goodwin. Further, a tentative suggestion as to the contemporaneity of the Neolithic and Bronze Ages in South Africa has before been put forward. The style and finish which these specimens present suggests the possibility of their being copies of bronze objects. They form thus a further step in the proof of the contemporaneity of these ages. The material of which they are composed was used in the construction of ornamental objects from the Zimbabwe culture. We may say, therefore, that these specimens form a link between the Neolithic, Smithfield, and Zimbabwe industries.

5. Acknowledgments.

My thanks are due to Professor Raymond A. Dart for causing me to undertake this work and assisting me by criticism and his own anthropological experience; to Dr. Alexander Galloway more especially for revising this paper; to Mr. L. H. Wells for his helpful interest and suggestions; to Mr. de Bruyn of the South African Institute for Medical Research for the photographs; to Mr. W. Girdwood for the diagrams; and to my uncle, Mr. T. Leask of Klerksdorp, through whom I obtained the specimens and who gave me the reliable information concerning their discovery.

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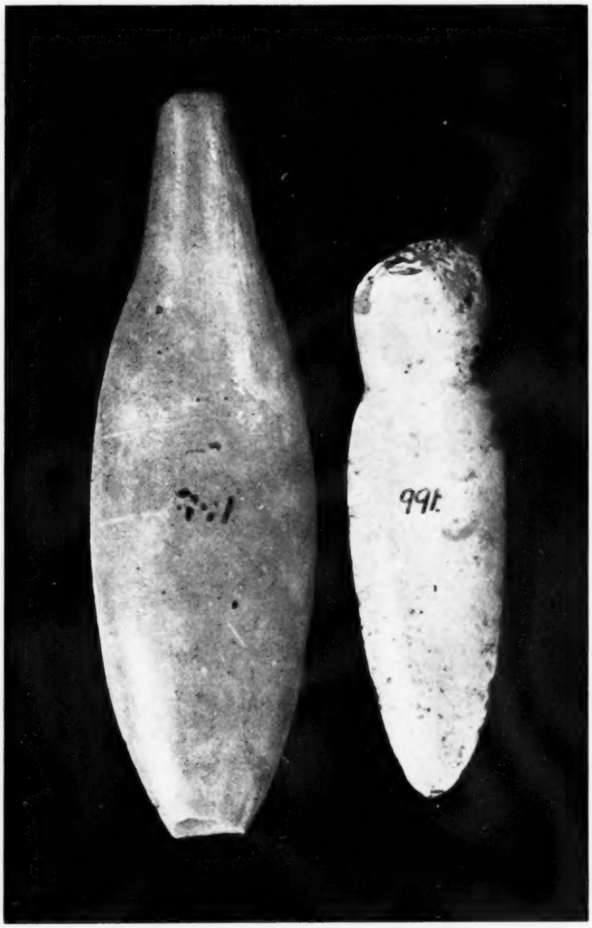


A. Specimen I } viewed from above.
B. Specimen II }

THE VEGETATION AND FLORA OF ROBBEN ISLAND.

By R. S. Adamson.

(With Plates XIII and XIV.)

(Read June 20, 1934.)

Introduction.

Robben Island, which lies off the entrance to Table Bay, is of especial interest biologically because rabbits were introduced by the early settlers, and it thus forms a confined area in which the vegetation has been under the influence of intensive grazing, which has not occurred on the mainland, where there are no rabbits.

The present account of the vegetation forms part of the results of a survey of the island undertaken by the Cape Geographical Society. A full account of the geographical features and history of the island is being prepared, and will be published elsewhere.

Visits to the island have been made in September, October, and March. During September 1933 a week was spent on the island.

Acknowledgments.

This opportunity is taken to express thanks to the Minister of Lands for granting permission to visit and to reside on the island, and for allowing the use of one of the houses during the stay made there. Thanks are also due to the Port Captain and Harbour Engineer at Table Bay, and to the various officers and others of the South African Railways and Harbours and of the South African Police, who provided transport to and from the island and assisted the work in many ways.

General.

Robben Island lies in lat. 33° 48′ S. and long. 18° 23′ E. It is 6 miles north of Green Point and about 4 miles west of the coast at Blaauwberg. In shape the island is oval, with the longer axis running north and south. It is about 2 miles in length and more than a mile across at the widest part.

The coast-line is devoid of distinctive features; for the greater part it is rocky, but shelving without cliffs.

A sandy beach occurs on the east side. Along the south-west coast for a distance of 800 yards a bank of stones has been formed above high-tide mark.

The interior of the island is generally low-lying; the highest point is 99·6 feet above sea-level, and is situated near the southern end. From this point the land falls evenly to the south and east, to the north more gradually, with a series of ridges and valleys running generally in the N.N.W.-S.S.E. direction. The higher ground, 60 feet or over, is all in the southern or south-eastern part of the island.

There is no surface water on the island except for temporary rain-pools in rocks or quarries. The inhabitants relied partly on rain-water and partly on boreholes. The latter were connected by pumps with a reservoir situated close to the lighthouse, which is on the highest point.

Historical.

At the present time the only persons resident on the island are the staff of the lighthouse and foghorn. But previous to 1931, when the population was evacuated, there had been a settlement for a long time with a population that at one time reached as many as 1500. The island has been used for a variety of purposes—recently as a leper colony, earlier as a convict station and for a criminal lunatic asylum. The occupied area is on the east and south-east side of the island, and is confined to a limited area. The greater part has never been enclosed or cultivated.

The inhabitants of the island kept cattle, sheep, goats, and other animals, though not in large numbers, and certainly cut shrubs for firewood. Rabbits were introduced by the early colonists of the Cape, and have flourished on the island. At the present time they are very abundant, and in the deserted condition that holds now their burrows occur everywhere.

Climate.

The general conditions of climate are very much like those of the adjacent mainland. The rainfall is intermediate in amount between that of Green Point on the one side and Blaauwberg on the other. The averages are: Green Point, 19·40 inches; Blaauwberg, 14·74 inches; and for the island, 18·27 inches. The rainfall is definitely of the winter precipitation type, 14·35 inches or 79 per cent. of the total falls during the six months April to September, and only 3·92 inches in the remaining six months.

The low-lying island is much exposed to wind, the general frequency

of which is the same as at Cape Town—west and north-west predominating in the winter months, and south and south-east winds in the summer months.

Geology and Soils.

The underlying rock all over the island is a hard slate rock belonging to the Malmesbury series. Over most of the area these Malmesbury rocks are overlaid by recent superficial deposits. The Malmesbury rocks on the island are an outcrop of the system that occurs on the adjacent coasts, at Blaauwberg and at Green Point. On the island these rocks are exposed along the coast-line, where they form a rather shelving though rocky shore. These rocks rise towards the centre of the island. At the south end they are exposed at the surface up to 25 feet above sea-level. Quarries have been worked in these rocks here. Further inland they are covered by sands, but one excavation in a ridge 65 feet above sea-level revealed these slates 14 feet below the surface.

The main mass of the island has a surface deposit of sands. In many of these a soft limestone has been formed at a distance of 6 to 18 inches below the surface. This limestone is friable and easily tunnelled by rabbits, whose burrows are principally situated in it. The limestone is white or cream coloured, and has no distinct stratification. It is rarely uniform, but is traversed by softer, often darker, coloured patches that suggest weathering and subsequent resolidification. In addition, more or less cylindrical slightly harder strands through the rock have the appearance of roots which have been replaced by lime. The thickness is uncertain; in some of the quarries and cuttings over 8 feet are exposed.

On the west side of the island at the base of the main sandy slope there is a solidified layer composed of shell debris. This is 15 feet above sea-level and forms a raised beach.

Just above the high-tide level along the south-west part of the island is a bank of stones. This bank extends for a little less than half a mile (800 yards) and runs parallel with the coast. It is 30 to 40 feet in width and 6 to 9 feet in height. It is made up of water-worn stones derived from the Malmesbury slates. At its northern end these stones are larger, 8 to 15 inches in longer diameter, smaller towards the southern extremity. In any portion of this rubble bank the stones are rather uniform in size.

The soils over practically the whole island are sandy or have an admixture of sand. Exceptions occur on the rock outcrops and locally on the beach, where small stones, gravel, or shells are heaped up. Apart from these, four types may be recognised—coastal-blown sand, sand with limestone, sand over Malmesbury slate, and the rubble bank.

The coastal-blown sand occurs on the east side in variable quantity,

but nowhere very deep. The sand is white with a high percentage of shell debris. It gives a vigorous effervescence with acid. The soils are unstable.

The sand with limestone occupies most of the island. The surface soil is 0 to 24 inches above the limestone. The soil is a pale sand without stones or gravel. It is lacking in humus, neutral or slightly alkaline, and gives no effervescence with acid. The soil above the limestone shows no definite stratification, but this is most probably due to erosion. All the vegetation is open, and the soil largely exposed in summer to wind erosion in addition to that caused by the rabbits. The appearance of the limestone on the surface is attributable to wind erosion. The soils over the Malmesbury slates are similar but shallow, 1 to 12 inches, and without the lime deposit.

The rubble bank has a dark sand between the stones.

The following table gives some features of these soils. A and B are from the sandy portions, in A the limestone being 18 inches below the surface, in B only 8 inches; C is from a portion with 9 inches of soil over slate; while D is from between stones on the rubble bank.

	P.H.	Loss on ignition (per cent).	Sedimentation (per cent.).				
			Coarse sand.	Fine sand.	Very fine sand.	Dark silt.	Black humus.
A	7·6	2·6	33	40	13	13	..
B	8·0	3·9	71	22	..	7	..
C	7·6	3·2	26	40	13	7	13
D	7·8	12·4	26	26	..	..	46

In sedimentation, after six hours the water in A, B, and C was very faintly opalescent, whereas in D it was distinctly, though not densely, cloudy.

The combination of very porous or shallow soils and definitely seasonal rainfall with absence of any surface waters produces conditions that necessitate drought resistance in the vegetation during the summer months. The conditions in winter and spring and in summer are very different as regards the water supplies.

Vegetation.

Throughout the island there is a decided uniformity both in flora and in the general character of the plant communities. All are open and composed of rather low-growing plants, which are generally

herbaceous or subherbaceous. For purposes of description a division of the vegetation can conveniently be made in accordance with the habitat, soil, and proximity to the sea. The main divisions are: sand with underlying limestone, flats over Malmesbury rocks, rocks and quarries, coastal rocks or stones, coastal sand, and the rubble bank. In addition there are the cultivated area and plantations.

Sand with Limestone.—This is much the most extensive, and covers the whole interior of the island. The vegetation is rather uniform over the whole area, and although differing locally in detail, does not show any distinct correlation with the surface features, ridges or valleys, or with the depth of the sand over the limestone.

Shrubby plants are generally absent; isolated bushes of *Lycium afrum* and *L. campanulatum* occur, and are very occasionally grouped in small thickets, but they are so infrequent that they in no way characterise the vegetation. The only other tall-growing plants, *Solanum sodomaeum* and *Ricinus communis*, are confined to quarries and disturbed areas.

By far the most abundant plants are *Anthericum divaricatum*, *Conicosia pugioniformis*, *Zantedeschia aethiopica*, and *Tetragonia fruticosa*. The first-named especially forms large sheets over much of the island, and occurs in all parts. These plants occur associated together or they may form practically pure patches that alternate. The patches may have sharp boundaries or pass gradually into one another. In neither case could any definite habitat factors be found which would explain the distribution. This seems to depend more on the growth habits of the plants, especially in the dry season, and the activities of the rabbits.

Anthericum does not seem to be eaten by rabbits, and is readily spread by wind, which bowls the dry inflorescences along in the early summer. These collect in masses against any obstruction. In the spring at the flowering period *Anthericum* forms an almost continuous cover where it is abundant as the inflorescence branches come in contact. The plant dies down in summer, but the new leaves appear during the dry period, and by March are 6 to 8 inches above the surface. This species thus leaves the soil surface exposed for a short period of time (Plates XIII and XIV, Photographs 1, 2, 4).

Conicosia pugioniformis is very often associated with *Anthericum*, though not so widely spread. It may form locally pure communities, but these are smaller and not extensive like those of *Anthericum*. No clear differences in habitat requirements of these two species could be made out. *Conicosia* is absent where the limestone is exposed at the surface, but elsewhere the two species occur mixed or in alternating patches. *Conicosia* has a less firm hold on the habitat than *Anthericum*; the succulent stems may reach 2 feet or more in length, but these die back in the dry season,

growth being continued from a bud some distance behind the tip. In very dry conditions the plant dies and is reproduced by seed. This arrangement allows the spreading of *Anthericum* into areas of *Conicosia* much more easily than the reverse spread. *Conicosia* seeds freely.

Tetragonia fruticosa is less abundant than these two species on the sands, but locally occurs in large quantity, even assuming an apparent dominance. It flourishes especially on the firmer shallower soils, and is absent from the deep loose sands. *Tetragonia* dies back to near the base of the shoots in the dry season, and as the leaves are nibbled by the rabbits in summer the plant often dies, and reproduction by seed becomes the means of survival.

Zantedeschia aethiopica occurs throughout the sandy parts, though generally in much less quantity than the others. It becomes exceedingly abundant in hollows and depressions, and especially at the base of the slope formed by the sand.

The only other persistent plant occurring in quantity is *Antizoma capensis*, which is confined to the sand on the highest part of the island. The shoots sprawl over the ground and frequently intertwine. This species may form continuous patches several yards across. *Antizoma* is a true perennial, retaining its leaves throughout the year, though in the dry period the whole plant may appear wilted. The other plants occurring in this habitat have a seasonal activity only. In the spring the vegetation appears quite luxuriant and in parts dense, but in the dry season the contrast is considerable, large areas of bare soil being exposed.

Of the spring flora *Oxalis cernua* is the most abundant species, and most conspicuous in its flowering period. It occurs most commonly in close association with the permanent plants and less in the open. The leaf blades in spring are eaten off by rabbits, though the other parts are untouched. In the dry season the rabbits burrow for the bulbs, and these factors seem to determine its distribution.

Other plants generally spread, but less abundant are *Homeria collina*, *Ornithoglossum glaucum*, *Anthericum ciliatum*, *Silene clandestina*, *Pharnaceum subtile*, *Hemimeris montana*, *Scirpus antarcticus*, and *Crassula glomerata*. *Romulea rosea* and *Haemanthus coccineus* occur locally in association with *Antizoma*. *Wahlenbergia arenaria* and *Cynanchum zeyheri*, though rare, are confined to parts where the limestone is at the surface.

Other species apparently confined to these sands are *Dimorphotheca pluvialis*, *Polycarena capillaris*, *Brunsvigia gigantea*, *Albuca fragrans*, and *Ehrharta villosa*. With the exception of the last all are of rare occurrence. *Ehrharta villosa* is a large grass that occurs in some quantity among bushes of *Lycium* or in tufts of *Tetragonia* or *Antizoma*. With it is associated, though in small quantity, *Exomis axyroides*.

Where the rabbits congregate, especially in regions of burrows for example, *Anthericum* and *Conicosia* are absent; the characteristic plants are *Pentzia tanacetifolia*, *Citrullus vulgaris*, and *Cucumis africanus*. These plants often occur in disturbed soils to the exclusion of all others, not only on the sand but in all the soils of the island. *Pentzia* flourishes in the spring and dries up in the summer, though the dead shoots persist: the other two flourish in the dry season. Both *Cucumis* and *Citrullus* spread over the surface, forming large patches. They are especially conspicuous towards the end of the dry season by reason of their remaining fresh and green when all other species are more or less dried up. Rabbits do not appear to touch the stems or leaves of either, though they eat the outer parts of the fruits of *Citrullus*.

Flats over Malmesbury Rocks (Plate XIV, Photograph 3).—This habitat forms a belt up to 300 yards wide at the north end of the island; elsewhere it is confined to patches near the coast. The most abundant plants are *Tetragonia fruticosa* and *Conicosia pugioniformis*. *Anthericum divaricatum* is generally present, and becomes very abundant, or even dominant, where the soil is deeper. *Oxalis cernua* is very abundant, but the other spring species are less common than on the sands. The red-flowered form of *Anagallis arvensis* is locally abundant. In one restricted area *Venidium hirsutum* is exceedingly abundant. The following occur with it:—

Venidium hirsutum (va).
Anthericum divaricatum (a).
Pentzia tanacetifolia (a).
Tetragonia fruticosa (f).
Oxalis cernua (f).
Conicosia pugioniformis (o).
Cryptostemma calendulacea (o).

A few species appear confined to this habitat, though all are rare: *Drosanthemun candens*, *Ehrharta brevifolia*.

Rocks and Quarries.—Apart from the coast, outcrops of rock are of limited extent, but those that occur bear a characteristic flora. *Asparagus capensis*, *A. medeoloides*, and *Ehrharta longiflora* are found here, also *Satyrium odorum* and rarely *Cyanella capensis*. One rib of rock, 8 yards by 2, situated 300 yards from the sea, bore the following flora:—*Asparagus capensis*, *A. medeoloides*, *Bromus patulus* var. *vestitus*, *Cenia turbinata*, *Ehrharta longiflora*, *Homeria collina*, *Hypochoeris glabra*, *Medicago denticulata*, *Oxalis cernua*, *Polycarpon tetraphyllum*, *Pentzia tanacetifolia*, *Romulea parviflora*, *Satyrium odorum*, *Senecio littoreus*, and *Tetragonia fruticosa*, with *Citrullus vulgaris* later in the year.

The quarries call for little notice. *Ehrharta longiflora* and *Senecio*

littoreus in spring and *Citrullus* later occupy the ledges. Various shrubby species find a possible place for germination in quarries, though eaten down elsewhere, e.g. *Acacia cyclopis* and *Myoporum laetum*. Some of these quarries hold rain-water, and such spots have provided habitats for *Lemna gibba* and *Crassula decumbens* and others.

Coast.—On rocks at or about high-tide mark, where sheltered from direct wave action, *Arthrocnemum rupicolum* occurs in considerable abundance. The plant may occur on stones or shingle, but is much more commonly on rocks. Along with it occurs also *Chenolea diffusa*, though in less quantity and usually slightly higher up. Neither species is touched by rabbits. At rather higher levels on rocks exposed to spray, but never submerged by sea-water, there are a few plants of *Spergularia media* and *Mesembrianthemum dunense.* The latter is much eaten by rabbits, and is only seen on rocks not at all easily accessible. On the rocks at higher levels there occur *Asparagus capensis*, *Tetragonia decumbens*, *Cryophytum crystallinum*, and *Pentzia tanacetifolia*. Shingle has been washed up in a number of small coves and bays and also on a more extensive stretch of shore on the west side. On this *Senecio maritimus* is much the most abundant plant. Associated with it are *Cryophytum crystallinum* and *Cotula filifolia*. *Tetragonia decumbens*, with *Oxalis cernua* and *Pentzia tanacetifolia*, occur on the upper parts of the beach. The *Senecio* forms a pure community on the seaward margin.

At the north end of the island are beaches made up of shells. On these *Anthericum divaricatum*, *Conicosia pugioniformis*, and *Pentzia tanacetifolia* occur down to the spring-tide mark. *Zantedeschia* occurs a few yards inland.

Coastal Sand.—Sand has been blown up on the east coast of the island. Strand plants are almost absent, though there are occasional individuals of *Cryophytum crystallinum* and *Tetragonia decumbens*, both of which occur where stones occur in the sand.

Low dunes have been formed of sand deposited on a bank of stones. These have a sparse growth of *Agropyrum distichum*, with a few tufts of *Ammophila arenaria*. Associated with the grasses are occasional plants of *Tetragonia decumbens*, *Ornithoglossum glaucum*, *Homeria collina*, and *Psoralea repens*. On the landward side are *Anthericum divaricatum*, and locally *Helichrysum crassifolium*. The last species was exceedingly abundant in 1932, but in 1933 appeared to have died out almost entirely.

Annuals are fairly abundant. *Silene clandestina* and *Pentzia tanacetifolia* are the most abundant; others in roughly decreasing order of frequency are: *Zalusianskya villosa*, *Crassula glomerata*, *Capnophyllum africanum*, *Hemimeris montana*, *Scirpus antarcticus*, *Urtica urens*, *Medicago denticulata*, and *Torilis africana*. Very occasional small plants of *Lycium*

afrum and *Myoporum laetum* occur, the latter spreading from a hedge on the land side.

Rubble Bank.—The vegetation on this bank varies in different parts, depending on the size of the stones, the amount of sand, and probably on the age of the bank. The bank has evidently been formed from north to south.

At the northern end a much denser vegetation occurs than further south. The most abundant plants are *Asparagus capensis* and *Tetragonia fruticosa*, which stand 2 to 3 feet high in a semi-open community. Along with them are scattered plants of *Anthericum divaricatum*. Below and extending between are masses of *Stapelia variegata*, which forms patches a yard or more across.

Other plants are: *Oxalis cernua*, *Homeria collina*, *Zantedeschia aethiopica*, *Ferraria undulata*, *Conicosia*, *Pentzia tanacetifolia*, and a very few plants of *Satyrium odorum* under the denser *Asparagus*. *Stapelia* and *Satyrium* are confined to the top of the bank and are absent from the slopes, and only occur at the northern end.

At the southern end the vegetation is much sparser and more open. Bushes are absent. *Anthericum* and *Conicosia* occur, but are widely scattered. *Ballota africana* is a characteristic plant where there is a little sand, and *Frankenia pulverulenta* occurs locally at the seaward margin. The most abundant plants are annuals and spring geophytes, such as *Pentzia tanacetifolia*, *Homeria collina*, *Erodium moschatum*, and *Cenia turbinata*.

Cultivated Area.—This occupies about a fifth of the area of the island. The area that has been enclosed is on the east and south-east sides of the island. The area extends along most of the east coast and is continued inland to the crest of the ridge of the island. At the south-east corner the fenced area extends to a point quite close to the lighthouse. Otherwise, except for a few isolated buildings, pumps, and plantations, the island is unfenced. A road has been constructed round the island quite near the coast, and another crosses the island from east to west about a quarter of the distance from the south end.

In the occupied area the roadways and boundaries have been planted with trees and shrubs. Of these very much the most abundant is *Myoporum laetum*, which appears well suited to the conditions. This plant grows fast and shows no sign of wilting in the dry season. The plant reproduces, but as it forms an important food for rabbits in the dry season seedlings only manage to survive here and there, either in inaccessible spots or as isolated survivors. All the trees have their leaves and twigs eaten off up to the height reached by a rabbit. *Myoporum* is planted, and is flourishing both close to the sea and further inland.

Other commonly planted trees are *Cupressus macrocarpa* and *Eucalyptus lehmanni*, but neither is as abundant as *Myoporum*. Many individuals of *Cupressus* have succumbed to the drought of summer. None are of large size, and many are misshapen. *Cupressus* shows no sign of reproduction. *Eucalyptus* has been planted mainly as a wind-break, and is especially common in parts of the area at one time used as the leper colony. It grows rapidly; reproduction occurs. Seedlings and young plants were seen among the stones forming the debris of houses that had been pulled down.

A number of other trees have been planted either as wind-breaks or for ornamental purposes, but none are at all numerous. A list of these is appended.

The land that was cleared or cultivated has, since its abandonment, become occupied by a vegetation very closely similar to that found on similar soils in other parts of the island. *Anthericum divaricatum* is generally the most abundant plant, but *Conicosia pugioniformis* and *Tetragonia fruticosa* also occur, although locally. As an example the area cleared and levelled as a cricket ground may be taken. Though this would not appear to have been a favourable site owing to the clearance and compression of the surface, after two years it was covered with *Anthericum*, which was so abundant that at the flowering time the inflorescences formed a continuous cover. Along with it were *Homeria collina*, *Pentzia tanacetifolia*, and a number of annual weeds. These latter species alone had established themselves on the hard portion used as the pitch.

At the southern end of the occupied area there is a stretch where the soil is a very shallow one overlying Malmesbury slates. This portion now has a flora almost wholly composed of weeds which flourish in spring. There are a few scattered plants of *Tetragonia fruticosa* and *Exomis axyroides*, which with *Citrullus vulgaris*, which is found throughout the area, form a very open community in summer. In spring, however, there is a quite thick growth of herbs completely covering the ground. The most abundant plants are *Bromus patulus*, *Medicago denticulata*, *Senecio littoreus*, *Homeria collina*, *Oxalis cernua*, and *Urtica urens*.

Plantations.—Outside the occupied area there have been established four small plantations. In three of these alternate rows of *Myoporum laetum* and *Cupressus macrocarpa* have been put in. In the fourth *Eucalyptus lehmanni* is also planted. These plantations are not very flourishing. Those near the coast, and especially those towards the south end of the island, have been much affected by wind: the trees on the exposed side are stunted and bent over. *Cupressus* has grown poorly in all, and there are many dead trees. The *Eucalyptus* in plantations has grown tall and straggling, with long stems bearing terminal tufts of leaves.

A few plants of *Acacia saligna* occur in one of these plantations, but are not flourishing. Under the trees in the plantations there are very few plants. *Zantedeschia aethiopica* flourishes though the plants remain widely separated. Otherwise the ground is bare or carries a few annual weeds.

General Discussion.

A comparison of the vegetation of the island with that on similar soils on the adjacent mainland brings out several very obvious differences. The island communities are of a very open character, and there is a marked absence of shrubs and woody plants. There is also a uniformity throughout, at any rate as far as the dominants are concerned. The flora is also relatively poor in species.

These characteristics can all be attributed to the activities of the rabbits, which have been confined to a limited area for a long time. Other modifying factors have operated, of course, such as human occupation, the introduction of some grazing animals, and burning; but these have played a small part as compared with the prolonged and continuous influence of the rabbits. This prolonged grazing in a small area has brought about the elimination of almost all plants except those which are untouched or used only as a last resource. This has reduced the vegetation to a very simple condition, and one decidedly uniform throughout.

Excluding species quite definitely planted or introduced by human agency, the flora of the island comprises 116 species of flowering plants. Of these 22 are confined to the occupied area or roadways, leaving 94 species composing the general vegetation. Of these only a few are at all common; these few occur on all habitats, and form throughout the characteristic species of the vegetation, and bring about the uniformity of the communities.

Associated with those common and generally distributed plants are a number of aliens or species doubtfully native. Many of these are widely spread through the island. Examples are: *Urtica urens*, *Emex australis*, *Polycarpon tetraphyllum*, *Medicago denticulata*, *Erodium moschatum*, *Euphorbia peplus*, and *Anagallis arvensis*. These are weeds which have been able to spread in the open communities. In addition to these there are a number of species that are confined to one of the types of habitat. These species are often rare, and many are small and inconspicuous, but they are to be regarded as relics of the flora of once definitely characterised communities related to the type of habitat. With the gradual elimination of a great part of the flora and the resultant spread of a few unattacked species which are not specialised in their habitat demands the original distinctions have been largely obscured.

As examples of these soil-localised species the following may be quoted: —(*a*) On sands with limestone: *Ehrharta villosa, Albuca fragrans, Brunsvigia gigantea, Haemanthus coccineus, Romulea rosea, Pharnacium subtile, Antizoma capensis, Cynanchum zeyheri, Polycarena capillaris.* (*b*) On slates: *Ehrharta longiflora, E. brevifolia, Drosanthemum candens, Senecio littoreus, Venidium hirsutum.* (*c*) On sand, both inland and coastal: *Scirpus antarcticus, Crassula glomerata, Hemimeris montana, Zalusianskya villosa.*

As might be expected, species of this class are most numerous and most conspicuous on the coastal habitats, rocks or sand. Character species of this kind may here be the dominant ones. The dominance of *Agropyrum distichum* on sand dunes and *Arthrocnemum rupicolum* on tide-washed rocks are examples. For a less extreme type of habitat the rubble bank may be taken as an example.

In all, 23 species have been noted for this habitat, of which 6 are among the very common generally spread species of the island. Three species are confined to this habitat—*Stapelia variegata, Ballota africana,* and *Frankenia pulverulenta*; the last is rare, but the others are quite abundant.

The same example of the rubble bank will serve as an illustration of the paucity of species in the communities on the island. A total of 23 species have been recorded, whereas on a corresponding bank on the Cape Peninsula a list of 75 species was made in a smaller area than the bank on the island. This Peninsula bank was composed of sandstone, not slate stones, but that difference cannot account for the discrepancy in the totals.

The lack of floristic variety is only one aspect, however; the island communities are much simpler in structure; bushes and woody plants are almost absent, and low herbaceous plants and annuals make up the communities.

For purposes of comparison with the island, the coastal vegetation on the mainland at Blaauwberg, and still more at Green Point (the nearest points with similar habitats and soil), has been much modified by human interference. Portions of the coast a few miles north of Table Bay do provide habitats essentially similar to those on the island and possess a vegetation that has been very little subjected to interference.

The coast opposite to Dassen Island is a suitable example. There is a rocky shore, with shell beaches in small coves, a narrow rock belt, and inland limestone with a sandy surface soil. The slope from the coast to the inland plain is much steeper than anything on the island, but otherwise the conditions are very closely comparable. On this coast the rocks close to the sea have exactly the same plants as occur on the island. The rocky belt above the high-tide limit, however, is very different. It has a dense though low-growing community of bushes with a large number of succulent

plants. *Asparagus capensis* is abundant and one of the plants coming closest to the sea, but is here mixed with many other bushes. *Mesembrianthemum dunense,* which is represented on the island by a few individuals confined to inaccessible rocks, is here abundant on shell beaches and shallow soils near the sea. It is one of the pioneers of the land vegetation.

The sand overlying the limestone inland is also covered by a community of bushy plants standing 1 to 3 feet in height. Among the bushes are a number of succulents, some of which are very abundant. The spectrum of this zone compared with that of the sand on the island will bring out the differences. It should be noted that the numbers of the annuals, geophytes, and hemicryptophytes on the mainland are probably too low, as the area has not been visited at the time of full spring activity. The succulents are grouped with the other plants of corresponding habit.

	Total.	M. and N.	Ch.	H.	G.	T.	E.
Mainland . .	82	27	24	9	17	20	2
Robben Island .	56	7	9	7	25	52	..

(The figures are percentages.)

In addition to the very decided difference in the distribution of the life forms, the vegetation on the mainland is closed, or nearly so, and not of the very open character of that of the island. Together with the open character the high percentage of annuals on the island indicates vegetation in an early phase of development and not fully stabilised.

In this mainland vegetation the majority of the species that are common in the communities on the island are present, but in very different proportions, and playing a very different part in the structure. *Tetragonia fruticosa* on the mainland is frequent on the rocky soils on the seaward margin of the sand. It is, however, always subsidiary to larger and more abundant bushes. It is very occasional further inland. *Anthericum divaricatum* and *Conicosia pugioniformis* are present, but occur only on the margin of the sand and on disturbed soils, such as the margins of tracks, eroded areas, and so on. Both are species of stages in the development of the vegetation and not of the stabilised communities. *Antizoma capensis* on the mainland only occurs in the vegetation of the level parts of the sand 50 feet or more above the sea-level. Here it is quite occasional. *Lycium* is common throughout, but never very abundant.

The existing vegetation of the island is to be regarded as consisting of the survivors from long-continued intensive grazing. The plants were

eaten down: those more or less untouched multiplied and spread over the area. *Anthericum* and *Conicosia*, both plants ordinarily of developmental phases and hence not very much specialised in habitat demands, have been especially successful. *Antizoma*, which has a more restricted habitat, has also increased with elimination of competition, but has not been able to extend beyond the limits of its original soil type.

In addition to the actual grazing, the disturbance of the soil by the burrows has certainly assisted in reducing the vegetation. This has further favoured those pioneer species which are not eaten. The present flora consists of relics which escape grazing or can withstand the disturbed conditions, together with immigrant weeds, most of which are aliens. The only shrubby plants are either poisonous or extremely hard and unpalatable, namely, *Lycium* and *Asparagus capensis*. A number of species seem to be maintaining a precarious hold, as several of the rarer species enumerated above which are confined to definite habitats.

The present vegetation cannot be regarded as having obtained a state of equilibrium in relation to the grazing pressure. Certain species at present seem to be in a state of diminution. *Tetragonia fruticosa*, though not eaten freely by the rabbits, is nibbled back in the dry season. This, combined with drought, causes death of individuals. Several patches were seen where *Anthericum* or *Conicosia* were spreading over dead *Tetragonia*. A more definite case can be seen with either *Satyrium odorum* or *Ferraria undulata*. Both are eaten freely, and plants only exist where given protection by bushes, especially the spiny *Asparagus*. In the case of *Satyrium* only one individual was found in flower, and this was in the midst of *Asparagus*.

In the dry season frequent excavations in the soil gave evidence of the attempts of rabbits to obtain food from underground organs. It is noteworthy that, excluding the untouched *Anthericum* and *Zantedeschia*, two of the most widespread of the geophytes are poisonous—*Homeria* and *Ornithoglossum*. The bulbs of *Oxalis cernua* are eaten in summer, but the plant easily holds its own owing to its efficient vegetative propagation. The absence of this species generally from open soil is due to bulb destruction.

The problem of the future of the vegetation is an interesting one well deserving careful study. At the present time the rabbit pressure has almost eliminated all but non-edible plants. No introductions are now taking place. How a balance can be maintained and of what nature it will be can only be settled by continued observation and record.

List of the Flora (excluding Planted Species).

	Sand.	Slate	Coast.	Rubble bank.	Cultivated area.
Ehrharta longiflora Sm.		×			
E. villosa Schult.	×				
E. brevifolia Schrad.		×			
Phalaris minor Retz.	×				
Ammophila arenaria L.	×		×		
Avena sativa L.					×
Cynodon dactylon L.	×	×			×
Poa annua L.	×	×			×
Bromus maximus L.					×
B. patulus M. and K. var. *vestitus* Stapf		×			×
B. unioloides HBK.					×
Agropyrum distichum Beauv.			×		
Lolium temulentum L.					×
Hordeum murinum L.		×			×
Scirpus antarcticus L.	×		×		
S. incomptulus Boek.	×				
Zantedeschia aethiopica Spreng.	×	×	×	×	×
Lemna gibba L.		×			
Ornithoglossum glaucum Salisb.	×		×		×
Anthericum ciliatum L. f.	×	×			
A. divaricatum Jacq.	×	×	×	×	×
A. sp.			×		
Albuca fragrans Jacq.	×				
Asparagus capensis L.		×	×	×	
A. medeoloides Thunbg.	×	×			
Brunsvigia gigantea Host.	×				
Haemanthus coccineus L.	×				
Cyanella lutea L.		×			
Romulea rosea Eckl.	×				
R. parviflora Baker		×		×	
Homeria collina Vent.	×	×	×	×	×
Ferraria undulata L.	×	×	×	×	×
Moraea xerospatha L.					×
Satyrium odorum Sond.		×		×	
Urtica urens L.	×	×	×	×	×
Australina capensis Wedd.					×
Emex australis L.	×	×			×
Rumex pulcher L.					×
Chenopodium album L.					×
C. rubrum L.					×
Exomis axyroides Fenzl.	×	×	×		×
Atriplex sp.			×		
Chenolea diffusa Thunbg.			×		
Arthrocnemum rupicolum Moss			×		
Pharnaceum subtile E. Mey.	×	×			
Tetragonia decumbens Mill.			×		
T. fruticosa L.	×	×	×	×	×
Cryophytum crystallinum N. E. Br.			×		
C. sp.			×		
Conicosia pugioniformis N. E. Br.	×	×	×	×	×
Drosanthemum candens Schwantes		×			
Mesembrianthemum dunense Sond.			×		
Spergularia rubra Pers.					×
S. media Pers.			×		
Polycarpon tetraphyllum L.	×	×		×	×
Silene clandestina Jacq.	×		×		
Antizoma capensis Diels	×				
Brassica sp.					×

LIST OF THE FLORA (EXCLUDING PLANTED SPECIES)—*continued.*

	Sand.	Slate.	Coast.	Rubble bank.	Culti-vated area.
Coronopus didymus Sm.					×
Crassula glomerata L.	×		×		
C. vaillantii Roth.		×			×
C. decumbens Thunbg.		×			
C. zeyheriana Schonld.	×				
C. umbellata Thunbg.					×
Acacia cyclopis Willd.	×	×			×
Medicago denticulata Willd.	×	×	×	×	×
M. maculata Willd. ?					×
Psoralea repens L.			×		
Trifolium tomentosum L.					×
Erodium moschatum Willd.	×	×	×	×	×
Oxalis cernua Thunbg.	×	×	×	×	×
O. corniculata L.					×
Euphorbia peplus L.	×	×	×	×	×
Ricinus communis L.					×
Lavatera arborea L.			×		×
Malva parviflora L.					×
M. sp.			×		
Frankenia pulverulenta L.				×	
Capnophyllum africanum Koch			×		
Torilis africana Spreng.	×		×		
Anagallis arvensis L	×	×			×
Asclepias fruticosa L.					×
Cynanchum zeyheri Schlecht.	×				
Stapelia variegata L.				×	
Ballota africana Benth.				×	
Lycium afrum L.	×	×	×	×	×
L. campanulatum E. Mey.	×	×	×	×	×
? *Physalis peruviana* L.	×				
Nicotiana glauca Grah.					×
Solanum sodomaeum L.	×	×			×
S. nigrum L.	×				
Hemimeris montana L. f.	×		×		
Polycarena capillaris Benth.	×				
Zalusianskya villosa F. W. Sch.	×		×		
Orobanche ramosa L.	×				
Plantago coronopus L.					×
Cucumis africanus L. f.	×	×			×
Citrullus vulgaris Schrad.	×	×			×
Wahlenbergia arenaria A. DC.	×				
Conyza ambigua DC.					×
Helichrysum crassifolium Less.			×		
Gnaphalium luteoalbum L.					×
Cotula coronopifolia L.		×	×		×
C. filifolia Thunbg.			×		
C. pusilla Thunbg.					×
Cenia turbinata Pers.		×		×	×
Matricaria sp.					×
Pentzia tanacetifolia Hutch.	×	×	×	×	×
Senecio maritimus L.			×		
S. littoreus L.		×			×
Dimorphotheca pluvialis Moench.	×				
Venidium hirsutum Harv.		×			
Cryptostemma calendulacea R. Br.	×	×			×
C. nivea Nicholls	×				×
Hypochoeris glabra L.	×	×			
Sonchus oleraceus L.		×	×		×

List of Planted Trees and Shrubs.

Araucaria excelsa R. Br.
Pinus halepensis Mill.
Cupressus macrocarpa Hartw.
Phoenix canariensis Chamb.
Casuarina cunninghamiana Miq.
Ficus carica L.
Bougainvillea glabra Choisy.
Phytolacca dioica L.
Acacia saligna Willd.
Schinus molle L.
Tamarix juniperina Bunge.
Dovyalis caffra E. Mey.
Leptospermum laevigatum F. v. M.
Eucalyptus corymbosa Sm. ?
E. corynocalyx F. v. M.
E. globulus Labill.
E. lehmanni Preiss.
Nerium oleander L.
Myoporum laetum Forst.

List of Species (other than Trees) Planted in Gardens, etc.

Pennisetum villosum R. Br.
Arundo donax L.
Aloe ferox Mill.
A. arborescens Mill.
A. saponaria Haw.
Yucca gloriosa L.
Allium oleraceum L.
A. sp.
Agave americana L.
Narcissus sp.
Chasmanthe floribunda N. E. Br.
"*Montbretia* sp."
Mirabilis jalapa L.
Phytolacca dodecandra L'Herit.
Mesembrianthemum sp.
Portulacaria afra Jacq.
Cotyledon orbiculata L.
Sempervivum spathulatum Hornem.
Crotalaria capensis Jacq.
Pelargonium zonale Willd.
P. peltatum Ait.
P. (garden hybrids).
Tropaeolum majus L.
Euphorbia polygona L.
Epiphyllum phyllanthus Haw.
Vitis vinifera L.
Hibiscus rosa-sinensis L.
Plumbago capensis Thunbg.
Vinca major L.
Acokanthera spectabilis Hook. f.
Ipomaea paniculata R. Br.
Echium fastuosum Jacq.
Chrysanthemum frutescens, L.
Artemisia absinthium, L.
Senecio angulatus, L.

Notes on Individual Species.

Homeria collina Vent.	Flowers medium reddish. Leaves usually with rust.
Anagallis arvensis L.	Only the red-flowered plant occurs.
Stapelia variegata L.	The great majority have typical flowers with dark markings on a yellow ground. A few have the dark colour very extensive and little yellow. The var. *atropurpurea* N. E. Br. was not seen.
Lycium afrum L.	There are two forms of this plant: (*a*) Flowers dark purple. Calyx segments acute, ciliate. (*b*) Flowers brownish. Calyx segments obtuse, densely fringed.
Plantago coronopus L.	Not previously recorded for the Cape. Confined to roads on the island.

DESCRIPTION OF PHOTOGRAPHS.

1. Slope near south end of island of sand over limestone. *Anthericum divaricatum* dominant. The smaller plants in flower are *Oxalis cernua.* The trees to the right of the lighthouse are a plantation of *Myoporum.* Photograph taken in October.
2. The same slope photographed in March. The paler band is a steeper portion where the limestone is close to the surface.
3. Vegetation on Malmesbury rocks near the coast at the north end of the island. *Conicosia pugioniformis* and *Oxalis cernua* are the most abundant plants. In foreground *Homeria collina*, *Anthericum divaricatum*, and *Pentzia tanacetifolia.* In the background a limestone slope and a portion of a plantation. Photographed in September.
4. Dry inflorescences of *Anthericum divaricatum* banked against the fence by wind. Tufts of leaves of this species at the left. The vegetation in the background is mostly *Tetragonia fruticosa.* Photograph taken in March.

PHOTOGRAPH 1.

PHOTOGRAPH 2.

PHOTOGRAPH 3.

PHOTOGRAPH 4.

Adamson. *Neill & Co., Ltd.*

STUDIES IN DECIDUOUS FRUIT.

I.—The Effect of Time of Picking on the Keeping Quality of Plums, with Especial Reference to the Internal Browning of the Kelsey Plum.

By I. Donen.

(Communicated by J. Smeath Thomas.)

(With Plate XV and two Text-figures.)

(Received and read June 20, 1934.)

Introduction.

The relation of the degree of maturity of fruit at picking and its bearing upon the subsequent development of physiological disorders in cold store have been stressed to a considerable extent during recent years. Various workers have already established the fact that cultural and environmental factors play an important part in predetermining storage life, but no direct correlation between particular orchard factors, such as climate, season, stock, manurial treatment, etc., and keeping quality of fruit, has as yet been clearly worked out (15). Observations by several researchers indicate, however, that by careful regulation of the date of picking, storage troubles such as internal browning of apples, Jonathan breakdown, bitter-pit, and scald can be almost entirely avoided (11, 4). Allen (1) found that there is a definite decline in the amount of bitter-pit development in Gravestein apples as the season advances, the amount of bitter-pit in the last pickings becoming negligible. Brookes, Cooley, and Fisher (2, 3) demonstrated that late pickings of York Imperial, Rome Beauty, and Grimes apples show greater resistance to scald than early pickings. These observations have been confirmed by Plagge (10) and by Gerhardt (5). The latter also observed that Grimes apples show an increase of breakdown with late picking. Harley and Fisher (7), on the other hand, found that Jonathan and Grimes Golden apples show in store a progressive increase of soft scald with increased ripeness at time of picking. Working on Bartlett pears, Harley (6) found that pears picked at an advanced stage of maturity break down at a more rapid rate than fruit picked earlier. He noted a close correlation between scald and breakdown, both of which he suggested

may be due to the same cause. Internal browning of Yellow Newton apples has been shown by Winkler (16) to be considerably increased by late picking. Haynes (8), working with Bramley's Seedling, noticed an increased breakdown associated with early picking. She ascribed this to the higher acidity of the early fruit, and suggested that breakdown might be almost completely avoided if apples were not exposed to low temperatures until their acid content became reduced. Plagge (9), experimenting with Jonathan and Grimes apples, found that deferred storage of the Jonathan apples strikingly increased the resistance of the apples to soggy breakdown. Postponing the storage date of Grimes apples, on the other hand, increases their susceptibility. Similar instances from the researches of other workers could be multiplied to show that while storage treatment is of fundamental importance, the degree of ripeness at time of picking also plays a significant part in predetermining storage life. Two conclusions are suggested:

(1) That no generalisation as to whether fruit should be picked when mature or immature is possible. Varietal and cultural factors are so great that it becomes essential to consider each fruit entirely on its own merits.

(2) That during the process of ripening chemical changes take place, which considerably affect and perhaps determine the susceptibility of fruit to breakdown in store.

Several ways of gauging the correct maturity of fruit are in practice. They are usually based on change of physical characteristics such as colour and firmness. It is acknowledged, however, that these methods are but rough indications of the correct picking time. Chemical changes in fruit, such as sugar-acid ratio, have been adopted as a criterion for export, and lately Reyneke and Du Toit (12) have suggested another criterion—the Index Figure—depending on the ratio of hydrogen-ion concentration of the fruit to its titratable acid. It is claimed that the "Index Figure" is an accurate and sensitive measure of the correct time of picking.

In order to throw further light on some of these problems a series of investigations connected mainly with the Kelsey plum have been started at the laboratories of the Chemistry and Botany Departments of the University of Cape Town. The storage experiments have yielded interesting results as far as the effect of time of picking on internal breakdown of the Kelsey plum is concerned. They are given here in the hope that they may be of some importance to the growers, but detailed discussion of the relationships between the chemical composition of the fruit and keeping quality in cold store is postponed until the next paper, to be published shortly.

Experimental.

The experimental work described in this paper was carried out with two varieties of Japanese plums—Gaviota and Kelsey. Samples were taken from four different orchards situated in the Stellenbosch, Somerset West, and Elgin districts, thus affording considerable differences in soil, and especially in climatic conditions. In each orchard, however, the plums were picked from trees as uniform as possible in regard to stock, age, growth, and soil conditions. Considerable difference was noticed in the times of "setting" and the appearance of the first flush of colour, which seems to be the most important criterion used by the growers in judging the correct time of picking.

Plums in the Somerset West orchard began to set in the middle of September, while at the Stellenbosch and Elgin orchards the setting of both Gaviota and Kelsey plums was delayed by about a fortnight. There was a corresponding lag in the time of ripening, so that when plums from the different orchards were picked for storage experiments they had been on the tree for very nearly equal periods.

The samples of the Gaviota plums were taken from three orchards, the number of trees from which the plums were picked in each orchard being about sixteen. The Kelsey samples, however, were picked from a much larger number of trees, and in each case represent an average of the crop of the whole orchard. Extreme variation in size was avoided. The stage of ripeness was judged by the appearance and physical properties of the fruit, the following stages being recognised:—

Under Ripe (U.R.).—Plums at dawn of colour, definitely too green for export.

Export Stage (E.S.).—These samples all showed the first flush of colour, and conformed to the stage judged by the growers to be suitable for export.

Late Export Stage (L.E.S.).—Under this head are included plums that showed all export qualifications but which ripened late. They, however, showed more colour than the Export stage, usually about 5 per cent.

Over Ripe (O.R.).—These plums were late pickings, considered by the growers unsuitable for export. They showed about 10 per cent. colour.

The fruit for each stage was picked on the same day. The dates of picking are given in Tables I and II. The fruit was wrapped and packed on day of picking in accordance with export requirements and put into cold storage the next morning. The plums were kept for the required time at 34°–36° F. in a modern commercial refrigerating plant which employed a forced draught air circulation.

TABLE I.

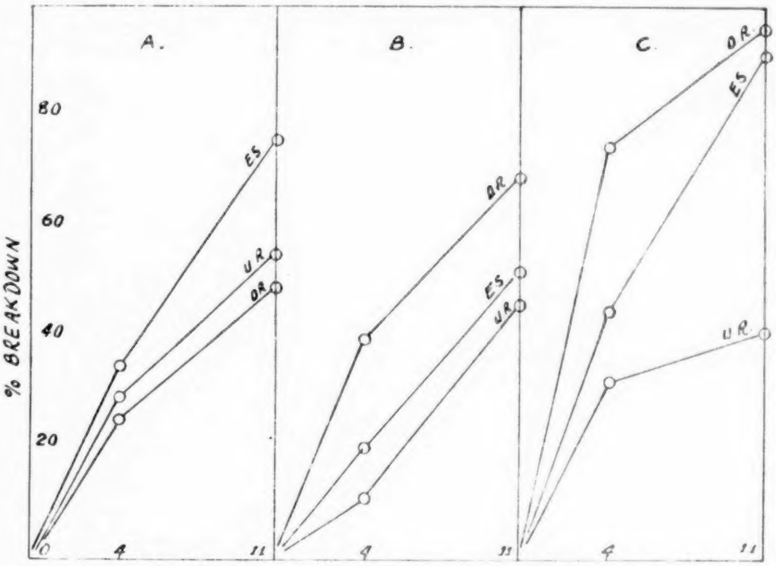
Orchard.	Stage.	Date of picking.	Percentage breakdown. Days in store. 30.	Percentage breakdown. Days in store. 56.	Days at 22° C. after 30 days in store. 4.	Days at 22° C. after 30 days in store. 11.	Condition of fruit after 30 days in store and 4 days at 22° C. Appearance.	Condition of fruit after 30 days in store and 4 days at 22° C. Flavour.
A	U.R.	Jan. 8	0	62	29	55	Light red. Firm.	Good.
A	E.S.	,,	0	85	35	76	Full red. Quite firm.	Fair.
A	L.E.S.	Jan. 16	0	78	20	60	Light red. Firm.	Indifferent.
A	O.R.	,,	0	100	25	49	Full red. Flabby.	Indifferent.
B	U.R.	Jan. 10	0	42	11	46	Light red. Very firm.	Good.
B	E.S.	,,	0	70	20	52	Full red. Firm.	Fair.
B	O.R.	,,	0	..	40	69	Full red. Firm.	Fair.
C	U.R.	,,	0	90	32	41	Light red.	Fair.
C	E.S.	,,	0	95	45	91	Light red.	Quite fair.
C	O.R.	,,	0	..	75	96	Light red.	Quite fair.

Incidence of breakdown in Gaviota plums in relation to degree of maturity.

GAVIOTA PLUMS.

The plums were kept for thirty days in store without pre-cooling, then placed at room temperature, average 22° C., for four days. This period was considered a fair test for the Gaviota plums, which ripen rather rapidly on removal from store. The plums were then kept under observation for a further seven days. In addition, a sample of each stage was kept in store for a period of fifty-six days and then examined. The average number of plums per sample was fifty. According to the degree of breakdown the affected plums were grouped as follows: Those showing complete breakdown; those showing a slight softening of the flesh; and lastly, those showing bladderiness. In computing total breakdown, all of these were added together. These details are not given in Table I, where total percentage breakdown only is given. It might be added that browning or collapse of tissue was not observed in the Gaviota plum.

A comparison of the results recorded in Table I shows that, except in two cases (A—Over Ripe, and C—Under Ripe samples), there is a definite parallelism between increase in rate of breakdown of plums exposed to room temperature after keeping in store for thirty days, and the increase due to longer exposure to cold storage conditions. It would seem, therefore, justifiable in the case of the Gaviota plums to assume that figures showing breakdown at room temperature represent very nearly the actual



Days at room temperature (22° C.) after keeping fruit for 30 days in store.

FIG. 1.—Rate of breakdown of Gaviota plums with maturity.

state of affairs, spread over a somewhat longer period, that takes place in cold store. The conclusion is also indicated that the average commercial cold storage period to which Gaviota plums are exposed should not exceed thirty days. The early pickings in orchards B and C show a definite superiority as regards keeping quality compared to later pickings. This is not borne out by the samples taken from orchard A, where the more mature plums show a relatively better keeping quality. The explanation might perhaps lie in the fact that plums in orchard A "set" much earlier than those in B and C, and samples Late Export stage and Over Ripe stage from orchard A represent pickings of plums which "set" late. This orchard is situated near the sea, whereas the other two orchards are situated

in highland country subject to different meteorological conditions. These results are shown graphically in fig. 1.

The plums of the Under Ripe stages coloured up very slowly in store. Their texture was much firmer than that of plums picked at later stages of ripeness, and the flavour seemed to improve greatly as soon as they coloured upon exposure to ordinary temperature. After four days at 22° C. all plums, irrespective of the stage of picking, turned a full red colour. It is interesting to note that the Gaviota plums remaining in good condition after fifty-six days in store showed hardly any colour—they were a uniform yellow, but had a decidedly good flavour. It seems, therefore, that Gaviota plums, for export purposes, should be picked early.

Kelsey Plums.

For this variety a sample of plums at Late Export stage picked from a fourth orchard, D, was included in the storage tests which were extended over thirty days in store and twelve days at room temperature, for Kelsey plums keep better in store than Gaviota. In addition, all four stages from orchard A were kept under observation in store for a period of one hundred days, and the rate of breakdown was determined. Samples usually consisted of about one hundred fruits for each stage. The tests with the Kelsey plums soon showed that they behaved in a somewhat different manner from the Gaviota variety. In general, two distinct groups could be distinguished: plums that behaved normally, and those that exhibited internal browning accompanied by premature breakdown and collapse of flesh.

Normal Plums.

Plums that behaved normally coloured up steadily and turned a uniform red after a few days' exposure to ordinary temperature. They finally reached a maximum stage of ripeness, began to soften—usually accompanied by a splitting of the skin—and then, when the tissue had become almost entirely disorganised, succumbed to fungal attack. The effect on such plums of storage periods longer than thirty days was a slowly increasing depth of colour, which reached about 90 per cent. after one hundred days in store. At the same time the plums began to soften, and the final samples removed from store showed as much as 80 per cent. breakdown of tissue with ripening. These changes are recorded in Tables II and III.

Internal Breakdown.

Plums of the second group failed to colour up either at room temperature or in cold store. Thus plums kept in store for one hundred and

TABLE II.

Orchard.	Stage.	Date of picking.	Condition and % colour of fruit.				Browning after 30 days in store and 12 days at 22° C.	
			30 days in store.	80 days in store.				
				Appearance.	% browning.	% bladderiness.	Condition.	% browning.
A	U.R.	1/29	10%.* Very good flavour.	Yellow.	100	17	Yellow. Bad flavour.	40
A	E.S.	,,	30%.* Very good.	30% colour.	100	50	Bad flavour.	44
A	L.E.S.	2/8	50%.* Good.	50–80% colour.	50	61	High colour.	9
A	O.R.	,,	50–70%.* 21% soft.	80% colour.	50	61	Over ripe. Full colour.	7
B	U.R.	2/5	Green. Good.	Yellow. Signs of collapse.	100	42	Yellow. Bad flavour.	45
B	E.S.	2/8	30%.* Good.	40–50%.* Signs of collapse.	100	44	Bad flavour.	68
B	O.R.	2/15	Soft.	60–70%.* Signs of collapse.	69	66	Yellow. Bad collapse.	63
C	U.R.	,,	Yellow. Fair.	Collapse and fungal rot.	100	..	Yellow. Bad flavour.	72
C	E.S.	,,	25%.* Fair.	25%.*	100	29	Bad.	70
C	O.R.	3/1	50–60%.* Fair.	60–90%.* Over ripe.	26	70	Full colour. Soft.	9
D	L.E.S.	2/6	40%.* Good.	Good. Full colour.	32	34	Full colour.	5

* Percentage refers to surface colour.

Incidence of browning in Kelsey plums in relation to the degree of maturity.

four days turned yellow and showed not more than 10 per cent. red. The first indications of physiological disturbance of such plums became evident a few days after removal from store. They seemed to become firmer, the skin became rough, and the base soon became streaked with translucent stripes. In a great number of these the skin soon began to shrivel, and after twenty-two days at room temperature practically all plums of this group showed collapse to varying degrees. The collapse was most pronounced around the base (see Plate XV, specimens D and E). Similar changes were also noticed amongst the plums kept in store, but only after

a considerably longer period. The translucent streaks became more prominently brown in store, but collapse of flesh was found to occur to a considerable extent only in the last samples. The marked shrinkage of volume at room temperature would therefore seem to be due to a considerable loss of water from the plum. On cutting open the plums showing internal breakdown, two definite types of breakdown were observed. For the sake of clarity they will be called Internal Browning and Invasive Browning respectively.

Internal Browning.

Browning of the tissue made its first appearance in the parenchyma immediately around the stone, and the zone of affected tissue slowly spread outwards until about 75 per cent. of the flesh was a dark brown mass, the vascular tissue remaining white and unaffected. Simultaneously with the spread of this browning there was an internal collapse of flesh which in the worst cases was accompanied by a shrivelling of the whole plum. At the same time a brown ring formed near the epidermis, which became hard and tough. The progressive changes are illustrated in Plate XV. There was a definite connection between the amount of browning and the extent of surface colour of the plum. At room temperature full-coloured plums hardly ever showed any browning. Those that were yellow on removal from store and that had coloured up to about 40–50 per cent. at room temperature remained firm, and usually showed only 10 per cent. browning of the tissue round the pit (Plate XV, B(ii)). Plums that coloured to the extent of 10–20 per cent. had about 50 per cent. of their flesh browned, while those with still less colour usually showed complete breakdown (Plate XV, specimens D and E).

The first onset of browning, which always began at the base of the plum, coincided with the appearance of the hyaline stripes previously described. There was a definite deterioration of flavour, and as soon as browning became at all prominent the plum became inedible. The rate of such browning in store was slow, but it was essentially the same as that noticed at room temperature, excepting that the extreme cases—shown in Plate XV, specimens D and E—were not encountered. Frequently a firm and healthy-looking plum, showing only 10 per cent. colour, was found when cut open to be completely brown. Even highly coloured plums, however, at the end of eighty days in store showed the beginnings of browning (see Table II).

Invasive Browning.

In addition to the physiological disturbance described above, which began at the pit and progressed outward, a second type of browning was

observed, which appeared as a narrow zone of brown tissue in the flesh of the plum near the skin and progressed inward. Some plums exhibited both types of injury, but many, especially those kept for long periods in store, displayed only invasive browning. In such cases the flesh around the stone had almost entirely broken down, and the fruit had more or less the character of a thick outer covering enclosing a fluid. On exposing these plums to room temperature they collapsed completely after a few days. Since this type of browning usually increased with longer periods in store, it is possible that such browning is due mainly to storage conditions. All pickings from orchard B were particularly prone to this malady. The less extensive occurrence in plums from other orchards might be due to inherent differences in the chemical and physiological conditions of these plums.

TABLE III.

Days in store.	% browning.				% bladderiness.	
	U.R.	E.S.	L.E.S.	O.R.	L.E.S.	O.R.
31	0	0	0	0	..	21
42	12	11	..	..	30	30
47	..	..	0	0		
49	41	43				
55	..	..	4	4	39	35
56	84	76				
62	..	..	6			
63	100	83				
70	..	..	11	17	50	50
71	..	95				
79	..	100				
81	..	..	50	50	61	61
101	..	..	72	..	81	66

Incidence of internal browning and bladderiness in relation to degree of ripeness of Kelsey plums at time of picking.

EFFECT OF MATURITY ON INTERNAL BROWNING.

The results of experiments on the incidence of browning in relation to the degree of ripeness at the time of picking are given in Tables II and III. The plums when taken out of store were all in good eating condition, but differed markedly in amount of colour. Except the Over Ripe stage from orchard A, all of them were very firm. After a few days, however, the plums which were picked early began to show browning and

soon became inedible. A small proportion of them coloured up fully in a manner similar to the late picked samples, which all became a uniform light red. Such plums passed their peak of ripeness in about eight days

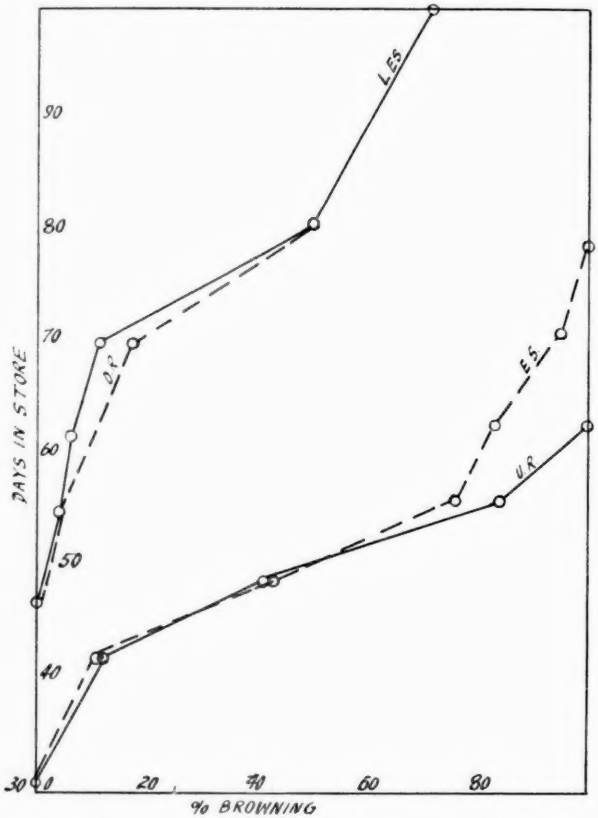


Fig. 2.—Incidence of browning with time in store.

at 22° C., and then became over ripe and somewhat watery. The occurrence of such plums among the Under Ripe stage samples is to be ascribed to the difficulty of selecting a uniform sample of fruit at the same stage of maturity.

The striking difference shown by the Late Export stage and the Over Ripe stage samples definitely indicates that Kelsey plums should not be picked for export unless they show at least 5–8 per cent. colour. Allow-

ing the fruit to hang on the trees until they attain fuller colour is not to be recommended, as such plums will soften considerably in store even after thirty days (*e.g.* A—Over Ripe stage). However, sample C—Over Ripe stage—picked very late in the season, showed extremely good keeping quality. This difference might be due to the slower rate of ripening of the plums in orchard C, where the heat during the summer months is not so intense.

The Late Export stage samples in orchards A and D exhibited less susceptibility to browning and to bladderiness than the other samples. It is therefore suggested: (*a*) that Kelsey plums should not be kept in store for a period much longer than thirty days; (*b*) that the late ripening, *i.e.* late "setting," plums are the best (see Tables II and III). Work on the effect of time of setting on rate of ripening and keeping quality is in progress.

Since all plums, irrespective of time of picking, sooner or later show browning in store, it seems possible that browning is entirely a storage disease. Unfortunately no tests on samples at ordinary temperature were carried out, and this therefore needs further confirmation. The greater susceptibility of the greener plums to invasive and internal browning would seem to be due to the metabolic changes which the plums undergo on ripening, and which serve apparently to increase the resistance of the mature plums to this malady. The difference in the rate of increase of browning in store with time of picking is shown graphically in fig. 2.

Possible Nature of Internal Browning.

As yet the writer has not been able to elucidate the biochemical nature of the internal and invasive browning in cold storage of the Kelsey plum. The work of some other investigators on a similar phenomenon in apples and pears is suggestive, and merits a brief consideration. The great similarity between the browning of plums and that of apples, as described and illustrated by Winkler (16) and Meiron Thomas (13, 14), suggests that the injury might be due to the same causes. Brooks, Cooley, and Fisher (3), working on apples, found that scald was due to volatile or gaseous substances other than carbon dioxide produced in the metabolism of the apple. Winkler came to the conclusion "that internal browning is due to the accumulation of essential oils or similar deleterious substances which are produced by the apples in storage." Working with Newton Wonder apples Meiron Thomas has definitely shown that internal browning and invasive browning of those apples are associated with an accumulation of ethyl alcohol and acetaldehyde, which are both formed during the respiratory processes which occur under anærobic storage or under the influence of certain mixtures of carbon dioxide and oxygen. Harley (6),

experimenting with Bartlett pears, and later Harley and Fisher (7), working with Jonathan apples, found that in store there is an accumulation of carbon dioxide in the intercellular atmosphere of these fruits. Under these conditions Harley (6) found a definite accumulation of acetaldehyde. The possibility of increase in concentration of carbon dioxide in fruit, even when placed in a well-ventilated store, was ascribed by Harley to difference in the skin structure of fruit, which in turn depends upon the degree of ripeness at time of picking. Since a definite change in the character of the skin prior to the occurrence of internal browning was noticed in the case of the Kelsey plums, and because of the similarity in the nature of breakdown between the plum and the apple, the view was naturally suggested that the internal browning in the plum might be due to the same cause. Preliminary attempts to isolate acetaldehyde were, however, not successful. More work on this problem will be carried out in the near future.

The Index Figure and Keeping Quality of Fruit.

Since the keeping quality of fruit is affected by the physiological condition at the time of picking, the claim put forward by Reyneke and Du Toit (12) that the "Index Figure gives an accurate measure of the degree of maturity and is a measure of the physiological condition at any moment" assumes considerable significance. They state that, "knowing the Index Figure at the time of picking enables one to foretell without great error the keeping quality" of the fruit. For the sake of clarity it might be explained here that by the Index Figure is meant the ratio of dissociated acid—as determined from pH values—to the total undissociated acid in the fruit, as measured by titratable acid. It is not intended to discuss here the theses on which the writers based their conclusions. It is necessary to add, however, that the Index Figure is a function of maturation, increasing to a maximum and then declining. Reyneke and Du Toit state that in the case of fruit containing starch those picked at the time corresponding to the maximum Index Figure should show the best keeping quality.

Index Figures of various samples were determined during the course of this investigation, both Gaviota and Kelsey plums being used. Average samples of twenty-five were taken from each group, cut up by hand, pressed, and the juice centrifuged. Determinations of pH values were made by means of a potentiometer, and hydroquinone electrode. Acidity was determined by titration of 10 ml. juice aliquots with N/10 NaOH, using phenolphthalein as indicator. The results obtained are given in Table IV.

The samples in the first column of Table IV were all picked on the same

day from Kelsey trees in orchard C. Each sample, however, was taken from a separate group of trees which had been especially treated with different fertiliser mixtures to determine their effect on the keeping quality of the plums.* The percentage breakdown of these plums after thirty days in store and twelve days at 22° C. are given alongside the corresponding Index Figures. In this group there is no correlation between Index Figure and percentage breakdown.

TABLE IV.

Kelsey plums. Orchard C.			Kelsey plums.			Gaviota plums.		
Sample.	Index figure $\times 10^7$.	% break-down.	Sample.	Index figure $\times 10^7$.	% break-down.	Sample.	Index figure $\times 10^7$.	% break-down.
(*a*)	21·01	36	A U.R.	23·14	40	A U.R.	28·44	29
(*b*)	20·70	88	A E.S.	22·80	44	A E.S.	26·05	35
(*c*)	20·50	54	A L.E.S.	22·03	9	A L.E.S.	24·87	20
(*d*)	20·31	62	A O.R.	17·54	7	A O.R.	24·42	25
(*e*)	19·72	73	B U.R.	18·81	45	B U.R.	23·59	11
(*f*)	19·50	78	B E.S.	16·91	68	B E.S.	21·84	20
(*g*)	19·10	54	B O.R.	15·63	63	B O.R.	21·08	40
(*h*)	18·95	72	C U.R.	20·08	72	C U.R.	41·05	32
(*l*)	18·90	81	C E.S.	18·14	70	C E.S.	35·29	46
(*m*)	18·80	45	C O.R.	22·97	9			
(*n*)	17·70	14	D L.E.S.	18·87	5			
(*p*)	17·50	44						

Correlation of "Index Figure" and keeping quality.

The samples in the fourth column were picked under conditions previously described. In the case of samples from orchard A the Index Figures of the different groups of plums lie on the descending portion of the curve, the Index Figures decreasing with maturity and the samples with lowest Index Figure show best keeping quality. Samples from orchard B are in no way conclusive. In those of orchard C the highest Index Figure is correlated with the time of picking that coincided with the best keeping quality.

The Index Figures of the Gaviota plums show a definite correlation with keeping quality. All samples from orchards B and C were picked on the same day and from the same limited number of trees. In orchard A the Under Ripe and Export Stage samples, and the Late Export stage

* These experiments were carried out by Dr. W. E. Isaac. The writer wishes to acknowledge indebtedness to him for supplying these samples.

and Over Ripe samples, were picked from the same trees but on different days. In this case the correlation for the whole A series does not hold.

Summarising these conclusions it is clear:—

(*a*) That there is no correlation between Index Figure and Keeping Quality if the plums are picked from different trees, even though in the same orchard and on the same day.

(*b*) That for different orchards the best keeping samples might sometimes have the lowest Index Figures, sometimes the highest Index Figures.

(*c*) That a correlation between Index Figure and Keeping Quality does exist if the plums are picked on the same day and from the same trees.

It is therefore suggested that, as far as the above results show, no generalisation as regards the Index Figure is justified.

Summary and Conclusion.

The effect of time of picking on the keeping quality in store of two varieties of plum (Gaviota and Kelsey) has been investigated.

The samples were chosen from four orchards differing in soil, climate, and cultural treatments. They were then kept at 34°–36° F. for thirty days and at room temperature for four or twelve days and the percentage breakdown recorded.

It has been found that Gaviota plums should not be kept in store for a period longer than thirty days, as breakdown increases greatly with increased time in store.

Gaviota plums that were picked early showed the least amount of breakdown.

Kelsey plums in store exhibit two types of breakdown: Internal and Invasive Browning. A description of these maladies and a discussion as to their possible nature is given.

The extent of browning of the Kelsey plum is associated with the amount of skin colour of the plum on picking. Early picked plums failed to colour up in store and showed high percentage of breakdown.

Plums picked with about 10 per cent. colour showed no browning after thirty days in store and twelve days at room temperature, but they coloured up fully, became over-ripe, and succumbed to fungal attack.

All plums, irrespective of time of picking, finally showed internal browning if kept in store for eighty days.

It is suggested that Kelsey plums should not be kept in store for periods much longer than thirty days, and that Kelsey plums for export should be picked with 5–8 per cent. colour.

The Index Figure is discussed in relation to breakdown in store. It has been concluded that, as far as these experiments show, no generalisation with regard to the Index Figure and Keeping Quality of fruit is justified.

In conclusion the writer wishes to thank Messrs. K. B. Quinan, A. C. Buller, P. Molteno, and F. Cartwright for kindly supplying samples, and Professor J. Smeath Thomas and the Chemistry Department of the University of Cape Town for affording the facilities which made this work possible. Thanks are also due to Dr. W. E. Isaac for valuable advice and criticism.

CHEMISTRY DEPARTMENT,
UNIVERSITY OF CAPE TOWN,
June 1934.

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Trans.

Donen.

A(i) B(i) C(i) D(i) E(i)

A(ii) B(ii) C(ii) D(ii) E(ii)

Donen. *Neill & Co., Ltd.*

THE SOUTH AFRICAN LITERARY AND SCIENTIFIC INSTITUTION, 1832–1857.

[Part of a Paper given at the Herschel Centenary, March 1934].

By LAWRENCE CRAWFORD.

(Read June 20, 1934.)

Any description of Sir John Herschel's activities at the Cape would be incomplete without some mention of the Scientific Society of which he was a strong supporter and for some time, immediately after his arrival, president. In one of his letters he wrote, "Rode into town to attend meeting of S.A. Lit. and Phil. Society at which I was elected an ordinary member and then chosen President for the ensuing year. Came home very much tired, partly with riding in the wind's eye, which I find very fatiguing." It must be remembered that he lived six miles from town and that this was long before trains or any service of public conveyance. I take this quotation from the article in the Cape Times of 15th January, but the true name of the Society was the S.A. Literary and Scientific Institution: it began in 1832 by the union of two earlier societies.

One of these was instituted in 1824, the South African Literary Society. At the first annual meeting, six years later, the Committee reported: "The Committee feels happy in being able to congratulate the Society upon its present flourishing state. The present Institution offers a striking example of a rising generation, showing inclination and desire for literature and knowledge. The history of every nation has shown the benefits derived from the operations of such societies. With these advantageous objects in view, a few respectable and patriotic individuals, in the year 1824, assembled together for the formation of this Society; but owing to some local impediments at the time existing, its regular and legal existence was reserved for the year 1829 when some of its old members, together with a few others, met on the 7th of February 1829, to take into consideration the expediency of its re-establishment. This having been agreed on, application for a licence was made to His Excellency Sir Galbraith Cole, which was immediately granted. Thus the Society having been legally re-established in June 1829, its annual meeting was determined to be holden on the first Saturday in the month of February."

The "local impediment" referred to was the opposition of the Governor at the time, Lord Charles Somerset. It was at a meeting held on 11th July 1824 that it was unanimously resolved to found a Literary Society, to ask Lord Charles Somerset to be patron and grant the Society a licence. The meeting was held at the residence of Messrs. Thompson and Pillans, and an address was given by Mr. John Fairbairn. He pointed out that Literary and Philosophical Societies were at that day numerous in most parts of the world, how every one present knew their nature and objects, how they were composed chiefly of lovers of natural science, but that such a society must not be open only to scientific men or directed exclusively to the cultivation of pure science, a taste for reading and enquiry must be encouraged as widely as possible in order to obtain a supply of members and correspondents: that having established a Society and a Library, a Museum of Natural History, Mineralogy, etc. would come as a proper appendage. He pointed out that at the same time it had been found a prudent measure and conducive to the peace and permanency of such a society to exclude some topics of great interest and importance, such as the conduct of existing governments, controversial theology, and, in slave countries, the subject of slavery. It was confidently believed, he said, that a Literary Society might now be formed in South Africa, and that there appeared no peculiar obstacle to obstruct its success.

The Governor did not wait for the deputation from the Society, but summoned Sir John Truter, the Chief Justice, who had been at the meeting. He gave him such a rating for joining the Society that Sir John had to withdraw his name. The Governor was even more distinct to Advocate Cloete, and informed him that he was resolved to crush the institution, adding with vindictive emphasis that it was quite sufficient for him to know that this Society originated with Mr. Pringle and Mr. Fairbairn—for he was fully determined so long as he held the reins of government to oppose and thwart everything, without exception, which emanated from them, or in which they were concerned. To show that he was in earnest, Mr. Fairbairn and Rev. Dr. Philip, who had also been at the meeting, and afterwards Mr. Pillans were officially summoned before the Fiscal and charged with holding "illegal meetings," a Proclamation dated 19th of January 1800, which had been issued by Sir George Yonge during the first occupation of the Colony by the British for the suppression of Jacobin Clubs, being read to them as the law which would be enforced in the present case should they venture to hold any further meetings. In his written reply the Governor said that the Society had been formed and established without any reference to the Executive Committee, so that he would be deviating from his duty in giving countenance to an establishment conducted by persons who had so wilfully paid so little regard to the authorities and established regulations

of the Colony. The chairman of the meeting, Mr. Blair, wrote in reply that at the meeting, even though the Chief Justice and other legal people were there, no one had thought any reference to the Executive Council necessary. Also in September a memorial from various people asking for sanction to the Society was forwarded by Thomas Pringle, then acting as Secretary; it stated that the rules and regulations were as in the Royal Society of London and the Asiatic Society of Calcutta. The refusal again of the Governor, who wrote that it was "inconsistent with duty to permit the establishment of an association which might have a tendency to produce political discussions," made it impossible for the Society to continue at that time.

Apparently another attempt was made next year to found the Society, for in the Archives there is a letter dated 22nd July 1825, asking for a licence to found a Literary and Philosophical Society; the first signature is that of the Rev. Fearon Fallowes (the first His Majesty's Astronomer at the Cape), and the Secretary of the movement was Dr. Andrew Smith, an army surgeon and an enthusiastic naturalist who had lately started a museum in Cape Town. Lord Charles Somerset was to be the patron, Sir John Truter and Sir Richard Plasket (Colonial Secretary, or Secretary to Government) vice-patrons, and the rules and regulations were to be modelled on those of other scientific societies which have stood the test of time and experience. There is no endorsement on the letter, and we must take it that the request was ignored or refused.

The S.A. Literary Society was thus in being in 1829 and a reading room was instituted, periodicals being got from England (including the Edinburgh Review and Blackwood's Magazine), France, Germany, and Holland. Prizes were instituted for composition in English and Dutch poetry and for a reply to a question tending to show the resources of the Colony and to the promotion of useful arts and sciences. It was also decided to give a prize to the student of the South African College, founded that year 1829, who should write the best English essay on a subject to be proposed by the Society. In the second report, dated 4th June 1831, there is a report of papers read on "The Introduction of Capital and Labour into the Colony," "Medical Statistics of the Colony," and "History of Dutch Literature." A gold medal, value £5, was offered to the student of the South African College for the best essay on "The Advantages to be derived from application to Study," and gold medals, value five guineas, were offered for essays in agriculture problems, but for these latter medals there seems to have been no competition.

Considering the smallness of Cape Town, it is surprising to learn that in the same month in which the Literary Society was revived a meeting was held and another society, on much the same lines, instituted. This was the

South African Institution, founded at a meeting on 17th June 1829, for investigating the Geography, Natural History, and general resources of South Africa. The chairman of the meeting was the Attorney-General, Mr. Anthony Oliphant (father of Laurence Oliphant, born that same year). A number of its members were also members of the Literary Society. In the South African Quarterly Journal, in which papers read before the Institution were printed, it is stated that the Institution was founded at the instance of the Governor, Sir Lowry Cole. He certainly took a keen interest in the Institution, and later the joint Society till his departure in 1833. In the report submitted in 1830 the award of medals is recorded, one to Mr. Bowie for a series of botanical notices, and one to Mr. Naude for a new model of carriage to be used in conveying any kind of goods. The judges gave a long report on this model and showed that the carriage did not have all the advantages it claimed, but they thought the work deserved encouragement. In the report of 1831 there is a statement that the Institution had held a Show of fruit and vegetables in February 1831, which had proved highly satisfactory: medals were awarded for fruit and vegetables, including bananas. This certainly seems to have been going outside the usual sphere of such a Society, but no agricultural society was then in being. A Society for the "Encouragement of Agriculture, Arts and Sciences in the Colony of the Cape of Good Hope" was established in 1800 at the instance of Sir George Yonge, then Governor. According to Theal, "beyond talking, this Society did nothing." Lady Anne Barnard was kinder and said a good amount of money was raised and that the Governor for once had reason to be pleased with his scheme. In any case it had a short life, and it was not till 1831 that again an agricultural society was formed.

To return to the South African Institution, in the year 1831 the number of members is given as fifty and subscribers fourteen. The report said that the attendance at times had been thin and discouraging, and put forward for discussion the problem which has come before every scientific society. Should meetings be held at night or in the afternoon? Nowadays, however, meetings could hardly be held at 3 p.m., the hour tried by the Institution instead of 8.

In 1832 the two Societies amalgamated and became the S.A. Literary and Scientific Institution, and the report of the new Society in 1833 stated that there were eighty-nine ordinary members and six subscribers, and that the "expectation of greater activity, on amalgamation, in researches had been realised mainly in the augmented value of the number of objects which adorn our Repositories." The acquisitions were Meteorological Instruments, additions to the collections and donations of a number of objects, from a young crocodile in spirits to the model of a self-acting field gate. The total value of the collection is put down as about £700. I think

it was in that year they were given permission to shoot some bontebok to add to their collection.

The President was Colonel Wade in that year 1833–34, Dr. Philip was a member of Council, and Dr. Adamson one of the Secretaries. Among the names of the members were Borcherds, Breda, Cloete, Chiappini, de Wet, Duthie, Ebden, Faure, Fairbridge, Gie, Hertzog, Jardine, Murray, Neethling, van der Riet, Stockenstrom, le Sueur, Smuts, Silberbauer, Tredgold, Truter, Versfeld, Watermeyer. Among the Hon. Members was Thomas Pringle, who had left the Colony in 1826.

It was at a meeting on 2nd August 1834 that Sir John Herschel was elected President, and the reports show that he was a strong supporter of the Institution. Reports of the meetings and papers read were published in the S.A. Quarterly Journal, vol. xi, 1833–35, and contained papers on African Zoology by Dr. Smith, plants introduced by von Ludwig, instructions for making and registering meteorological observations by Herschel, progress and present state of Geographical discovery in Central Africa.

Even Herschel's instructions did not make a number of people competent to make observations, for years afterwards Sir David Gill spoke on Meteorology and its discordant results on rainfall in the country; how on investigation observers even of that were found to be bad. One had used his rain gauge for shooting practice, and another had kept his indoors and only put it out when he thought it was going to rain.

The Report of the Institution in 1835 is one of the latest papers in the Journal, and it may be remarked that the income for the year past was £175, the expenditure £141, the balance £34, but that there was an outstanding claim for £36. The Report also said that "difficulties in regard to issuing of publications (of the Journal) had not been removed." In that year the S.A. Quarterly Journal came to an end: there are no further publications of reports of the meetings and of papers read, and information about the later history of the Institution is difficult to find. Unfortunately the Society's own minute books, etc., have disappeared.

A big thing organised earlier by the Institution was an expedition to Central Africa. It must be remembered that "Central" Africa then is not what we mean now, and that the expedition, while not intended to go beyond lat. 23° 30′, did not get further north than lat. 24° 30′ (Pretoria is about lat. 25° 30′). The Institution founded the Cape of Good Hope Association for exploring in Central Africa, asking citizens to take up shares of £3, and appealing for funds to the Secretary of State for the Colonies. Dr. Smith was appointed head of the Expedition.

The Expedition started for Graaf Reinet, went north to Philippolis, then east to the Caledon River, visited Wesleyan Mission stations there and

penetrated into Basutoland, where they visited Morija and interviewed the chief, Moshish. Later they came back to Philippolis and then went north, and came to Kuruman where the Rev. Mr. Moffat was missionary. With him they went on to the Molopo River, and still further north visited the chief, Umsilikazi, better known as Moselekatse, the head of the Matabeles. On their return journey south they also visited the chief Waterboer at Griquatown, who had in 1834 entered into a treaty with the English authorities in S. Africa. After the return in 1836 a meeting was held at Cape Town, with Sir John Herschel in the chair, to hear the report of the expedition, and it was decided to continue this association for exploration, but its subsequent proceedings are lost to us.

In the Cape Almanac for 1836 there is a description of the Institution: The society's rooms are situated in Looyer Plein, near Government House, where they have a very beautiful museum filled with specimens of animals and other natural objects indigenous to South Africa, besides others from various parts of the world, to which strangers are admitted on payment of 1s. each. Ordinary meetings of the Society are on the first Wednesday of each month at 3 o'clock, where original communications are read and scientific subjects discussed. New members are admitted by ballot and on the proposal of two members, entrance fee is £3, and the annual subscription is £1, 10s.

In the Commercial Advertiser a full account is given of the meeting of the Institution to say farewell to Sir John in 1838:

"*10th March* 1838. A meeting of the S.A. Literary and Scientific Institution was held to take leave of Sir John Herschel who has for nearly three years held the office of President of the Association. The following address was presented: 'The Council and members of the S.A. Literary and Scientific Institution would respectfully express their deep regret that by your approaching departure from the Colony they must lose the singular advantages bestowed on them by your holding, during your residence here, the office of their President.

"'They most gratefully express their acknowledgments for the interest conferred on their meetings by the notices which you have in that capacity kindly laid before them in respect to the general progress of men in all departments of science, and especially for the information at all times liberally offered to them, in respect to those great divisions of knowledge cultivated by yourself, and the varied incidents which your observations have continually presented.

"'The Institution has been by your means brought into correspondence with eminent men and with societies for similar objects in other lands, and may thence expect to derive advantages beyond which it is entitled to claim by its limited resources and endeavours.

"'The reports with which you have favoured the Institution on the subject of meteorology, and the proposals contained in them for the advancement of that science, have tended much to awaken a universal interest

in its importance, and to combine and direct the efforts of observers over the world.

"'We assure you that we will ever remember the kind sympathy and interest you have shown in our endeavours, and we hope that Providence will be watchful over you, and afford means and opportunities by which society may be still further benefited by your exertions, and may continue to afford that eminent place in its respect which the highest attainments and discoveries may claim.

"'We respectfully request your acceptance of a medal in gold with the device of the Institution as the only mark of respect at present in our power to bestow.

"'We hope that we may be permitted still to consider you as Director of the Committee for Meteorology, and that the correspondence in regard to that object may take place which you have kindly proposed.'

"The Medal was then presented by the Vice-President (Thomas MacLear in the Chair).

To Sir J. F. W. Herschel, A.B., KNT., G.H., etc., etc.,
late President of the
South African Literary and Scientific Institution.
Presented
by its members as a humble acknowledgment of his earnest and assiduous zeal for its interests. A.D. 1838.

"Sir John replied in terms expressive of his regret at leaving a country where he had lived three years in great happiness, in the enjoyment of an intercourse of uninterrupted kindness on the part of those whom he met, and of his continued interest in the Institution and of his readiness to forward measures for its benefit."

In the issue of 10th November 1838 of the same newspaper there appeared an advertisement of a meeting to be held to consider the question of erecting a monument on the site of Herschel's telescope at Claremont, and asking for subscriptions. The amount oversubscribed for the medal was handed to this fund and on 28th November 1838, at a meeting in the Commercial Exchange with the Governor in the chair, it was resolved to put up the obelisk which now stands there.

After 1838 I can find no reference to the Institution for a number of years, but I think that a serious check to its scientific activities and to the desire of members to do research work must have been that there was no publication of papers given to the Society. Every science worker wishes to make known the results of his research, and is discouraged if his finished work lies unknown. There is no doubt but that the Institution declined, so much so that Fairbairn, even though he had been one of the founders of the original Society in 1824 (he must have resigned almost immediately after, or on the amalgamation of the Societies, for his name is not on the

list of members in 1833), wrote in his paper, The Commercial Advertiser, on 22nd May 1850, that there was then a favourable opportunity for forming a Literary and Scientific Institution in Cape Town. He suggested that to have the Society on a stable foundation it should be attached in some way to the Public Library. On 1st June he wrote "The same proposal (to found a Literary Society) was made by the writer in 1824. The scheme was checked for the time, by the interference of Government, to which discussion, verbal as well as printed, was then extremely obnoxious. Some years afterwards the Society was revived, but declined from many incidental causes which no longer exist." Nothing seems to have come of this appeal. The S.A. Literary and Scientific Institution still continued, and it is not till the year 1858 that its name disappeared from the list of Societies in the Almanac and Annual Register: we may take it, then, that the Society died in 1857. But two years earlier it signified its intention of handing over the remnants (inauspicious word) of its collections, books and instruments to the new S.A. Museum which was founded in that year. This statement is made in the first annual report of the Museum in 1856.

I must not fail to acknowledge assistance from the authorities of the Public Library, the Archives, University Library, the Museum and the Argus Bureau, to them and all these people whom I have consulted I give sincere thanks.

CAPETOWN, 1934.

ACKNOWLEDGMENT.

The Council desires to express its thanks to the Research Grant Board for the receipt of a grant towards the expenses of printing the following papers which have appeared in the Transactions:—

K. H. BARNARD. "South African Caddis Flies (*Trichoptera*)," vol. xxi, pt. 4.

C. VON BONDE. "The Morphology of *Balanoglossus capensis* (Gilchrist), a Species of Enteropneusta from False Bay," vol. xxii, pt. 1.

THE TRIGLIDAE OF SOUTH AFRICA.

By J. L. B. Smith.

(With Plates XVI–XXIII and one Text-figure.)

(Read May 16, 1934. Revised MS. received June 18, 1934.)

Family TRIGLIDAE.

Four genera of this family are admitted by Barnard (Ann. S.A. Mus., 1925, vol. xxi, p. 938) to the South African fauna list, viz. *Trigla* Art., *Peristedion* Lac., *Lepidotrigla* Gnthr., and *Chelidonichthys* Kaup.

An examination of the material in the collections of the South African Museum and of the Albany Museum indicated that a revision of the South African species of this family was necessary.

A new sub-genus of *Trigla*, *Trigloporus*, and three new species, are described below.

Key to the South African Genera.

I. Lateral line without spines.
- A. Scales small to moderate, less than 70 in lateral line . . . *Lepidotrigla*.
- B. Scales very small, more than 70 in lateral line . . . *Chelidonichthys*.

II. Lateral line spinose.
- A. Body covered with bony plates, each bearing a spine. Preorbitals produced . . . . *Peristedion*.
- B. Body scaly. Preorbitals not produced. Whole body covered by a complex muciferous tube system. Lateral line scales with several spines . . . *Trigla* (*Trigloporus*).

Genus Lepidotrigla Gnthr.

1925. Barnard, Ann. S.A. Mus., vol. xxi, p. 938.

Body covered with scales of moderate size, ctenoid, or ctenoid above lower third of side, cycloid ventrally. Breast naked, or partly scaly. Lateral line bifurcates at caudal base, the branches extending on to the caudal lobes. Lateral line tubes with one long oblique dorsal and a similar ventral branch, and one to six intermediate smaller branches, each ending in a pore.

No spines on lateral line scales, which are somewhat larger than the

body scales, being vertically elongate. Teeth in jaws and usually on vomer; palatines edentate. Three free pectoral rays. A row of spinose plates along each side of the base of the dorsal fin.

This diagnosis, where amended, is based upon South African material only.

The species of this genus appear to be fairly numerous, but they have received relatively little attention from systematists, and the relationships o not appear to be well established.

Of the features upon which differentiation may be based, the number and nature of the preorbital spines appear to be of special significance, but these have apparently received little attention, and they have not been described as minutely as they merit. The shape of the spinous dorsal is also of assistance, but is evidently somewhat variable even in one species, *e.g.* in *natalensis* G. and T. the 3rd spine varies from 1·0–1·2 times the length of the 2nd. The number of serrae on the 1st dorsal spine may also prove of assistance in differentiation.

These fishes appear to be found below the 20-fathom line, and being of small size and relatively few in number, have at present no economic significance, in South Africa at least. All of our specimens have been obtained in Natal waters, and may ultimately be found in other parts of the Indo-Pacific area.

The South African species first obtained and described by Gilchrist and Thompson (Ann. S.A. Mus., 1914, vol. xiii, pp. 75, 76) were *faurei* and *natalensis*. Barnard (Ann. S.A. Mus., 1925, vol. xxi, p. 938) later united these species under *faurei*, which has page-preference over *natalensis*.

A careful study of the material believed to have been used by the original authors reveals that *natalensis* should be revived, but chiefly upon features not noticed by Gilchrist and Thompson. As will be shown below, it is not indeed certain that the specimen now described as *faurei* is one of those described by the original authors.

A new species, *multispinosus*, well differentiated from our and from other Indo-Pacific species, has been added.

Key to the South African Species.

I. No keel on preopercle. Six or fewer preorbital spines. Pectorals longer than head.
  - A. A patch of scales on breast. Two outer preorbital spines abruptly longer than the subequal inner spines . . . *faurei.*
  - B. Breast naked. Two outer preorbital spines not abruptly longer than the graduated inner spines . . . . . *natalensis.*

II. A strong keel on lower margin of preopercle. Ten or more spines on each preorbital. Pectorals shorter than head . . . *multispinosus.*

In the following descriptions "length of head" is the distance from the hind margin of the upper portion of the opercular flap (*i.e.* excluding the projecting portion of the opercular spine) to the tip of the longest preorbital spine. This is in most cases practically the same as the distance from the hind margin of the opercular flap to the mid-point of the snout between the preorbital extensions, measured obliquely.

Total length is measured from the tip of the longest preorbital spine to the apex of the mid-caudal rays.

Lepidotrigla faurei G. and T.

(Plate XVI, A; Plate XVIII, A; Plate XIX, A, C.)

1914. Gilchrist and Thompson, Ann. S.A. Mus., vol. xiii, p. 75.
1925. Barnard, Ann. S.A. Mus., vol. xxi, p. 938.

Depth 4·1, length of head 3·1 in length of body. Eye 3·9, interorbital 4·9, snout (to tip of preorbital spine) 2·6, distance between apices of longest preorbital spines 3·5 in head. Dorsal profile of snout steep, almost straight. Snout between the projecting preorbitals scarcely emarginate. Preorbitals each with 6 spines, the outer 2 large, subequal in length, the inner 4 subequal, very abruptly smaller than the outer (Pl. XVIII, A). No preopercular spine or keel. Two inconspicuous spines on supero-anterior margin of orbit. A short transverse groove at the supero-posterior margin of each orbit. Nuchal spines feeble, reach beyond the base of the 3rd dorsal spine. Opercular and humeral spines moderate. Jaws with bands of small conical teeth. Vomerine teeth doubtful. Palatines edentate. Pyloric caeca cannot be determined as the intestines have decomposed. Seven gill-rakers plus several rudiments.

D VIII + 16, inserted above the hinder third of the opercular flap. 1st, 2nd, and 3rd spines serrate, 38 serrae on 1st spine, those on 3rd spine very small. 1st spine 2·0, 2nd 1·7, 3rd 1·6 in length of head. 4th–6th dorsal rays longest; 5th ray 1·9 in head, 5·7 in length of body; 14th ray 2·3 in head, 7·0 in length of body. 14th ray laid back just reaches upper margin of caudal base.

A 16, inserted below the soft dorsal origin. Lower than soft dorsal.

P 11 + 3, 1·13 times head, 2·75 in length of body; tip reaches to below the base of the 7th dorsal ray, and to below the 29th lateral line scale. First upper and lower three of connected rays simple. Longest free ray 1·3 in head, tip does not reach ventral tip.

Ventrals 1·2 in head, reach to base of 3rd anal ray.

Caudal slightly emarginate, peduncle 1·4 times eye.

Scales moderate, ctenoid dorsally to level of humeral spine, graduated into cycloid on ventral area (Pl. XIX, A and C). Lateral line scales 60;

tubes with 3–8 branches, longest above and below. No pores on body. 22 spines along dorsal base. Breast with a median patch of moderate cycloid scales.

Colour.—Preserved, uniform red-brown. Inner surface of pectorals dark, with light margin above and below.

Length.—143 mm. (S.A. Mus., No. 11803).

Locality.—Natal, off Tugela mouth, in 20–63 fathoms.

In the South African Museum are eight adult specimens of *Lepidotrigla*, these having been registered as the material, collected by the s.s. "Pieter Faure," upon which Gilchrist and Thompson based their diagnoses of *faurei* and of *natalensis*. These eight specimens have the following numbers, lengths, etc.:—

S.A.M. No. .	11797	11797	11797	11803	11812	11812	11812	11812
Total length .	178	174	160	143	167	162	155	135
Body length .	154	149	134	120	144	136	130	120
Dorsal spines .	9	9	8	8	9	8	8	8

According to the South African Museum register, two of the three of No. 11797, plus No. 11803, are Gilchrist and Thompson's orthotypes of *faurei*, and one of those of No. 11812 is the holotype of *natalensis*.

According to Gilchrist and Thompson (*loc. cit.*), the three types of *faurei* were of length 120 mm., 120 mm., and 146 mm. None of the above are as small as 120 mm., unless these authors recorded body and not total length. Otherwise, some of their measurements were erroneous, or there has been a loss of specimens.

In the case of *natalensis* the holotype was stated to be 120 mm. in length, and it is possibly the smallest of those of No. 11812. In any case, there has obviously been some lack of care in the designation and preservation of Gilchrist and Thompson's orthotypes, which is particularly regrettable in the present case, since a careful study of the eight specimens reveals that No. 11803 is well differentiated from the remaining seven, which are undoubtedly conspecific.

The original descriptions of *faurei* and of *natalensis* reveal nothing of significance whereby these two species may be distinguished from each other. *L. faurei* was stated to have "two strong spines" on each preorbital, and ctenoid scales, and *natalensis* to have "a row of strong spines" on each preorbital, and cycloid scales.

None of the eight South African Museum specimens have only two preorbital spines, but in No. 11803 the two outer are very abruptly longer than the subequal inner spines (Pl. XVIII, A). In none of the remaining

seven specimens are the two outer spines so abruptly differentiated from the inner (Pl. XVIII, B and C). Further, in all of the specimens, the scales above the lateral line are ctenoid, but cycloid on the ventral surface.

It is therefore impossible to select with certainty the orthotypes of Gilchrist and Thompson, but there is no alternative except to revive *natalensis*. In view of the nature of the preorbital spines of No. 11803, this (a ripe female) is here designated the holotype of *faurei*, and the remaining seven specimens (male and female) listed above may be designated the lectotypes of *natalensis*, or, alternatively, No. 11812 of length 135 mm. might be selected as the orthotype.

L. faurei is well differentiated from *natalensis* not only by the nature of the preorbital spines, but also by the presence of scales on the breast, and by the longer pectorals and soft dorsal rays. The scales of *faurei* are more strongly denticulate than equivalent scales of *natalensis*.

It is, however, remarkable that among over 50 juvenile specimens, taken with these eight adults, none show any signs of a scaly breast, and should no further specimens of *faurei* (as here defined) be discovered, it may be suspected that it is merely an abnormal specimen of the form now recognised as *natalensis*.

Lepidotrigla natalensis G. and T.

(Plate XVI, B; Plate XVIII, B, C; Plate XIX, B, D, E, F.)

1914. Gilchrist and Thompson, Ann. S.A. Mus., vol. xiii, p. 76.
1925. Barnard, Ann. S.A. Mus., vol. xxi, p. 938 (*faurei* part?).

Depth 4·0–5·0, length of head 3·0–3·2 in length of body. Eye 3·4–4·0, interorbital 4·0–5·0, snout (to tip of preorbital spine) 2·2–2·5, distance between apices of longest preorbital spines 3·2–3·7 in head. Dorsal profile of snout steep, almost straight. Snout between the projecting preorbitals almost straight to emarginate. Preorbitals each with 4–6 spines, the outer the largest, graduated to the inner, no abrupt change in size (Pl. XVIII, B and C). The form and arrangement of these spines are somewhat variable, and some specimens have 1–2 outer smaller spines at the base of the largest. In very young specimens there are rarely more than 2–3 spines visible, and these are highly incurved, as if the spinose preorbital extension develops from the inner side with growth. No marked pre-opercular spine in adults; a small pungent spine in very young specimens, which becomes more or less obsolete with growth. No preopercular keel. Two inconspicuous spines on supero-anterior margin of orbit; there are 2–3 moderately prominent spines in juveniles which diminish with growth. A short transverse groove at the supero-posterior margin of each orbit, obscured on one or both sides in some specimens by an outgrowth of the

bony integument. Nuchal spines fairly strong, reach from almost below to beyond the base of the 3rd dorsal spine. Opercular and humeral spines moderate.

Jaws and vomer with bands of small conical teeth. Palatines edentate. Gill-rakers 7–9 plus several rudiments. Pyloric caeca 6–8.

D VIII–IX + 16, inserted above the hinder third of the operculum. 1st, 2nd, and 3rd spines serrate, 42–46 serrae on first spine, those on 3rd very small. 1st spine 1·7–2·1, 2nd 1·6–1·8, 3rd 1·5–1·7 in length of head. 3rd spine 1·03–1·2 times second. 4th–6th dorsal rays longest; 5th ray 2·1–2·5 in head, 6·2–7·0 in length of body. 14th ray 2·6–2·7 in head, 8·0–8·6 in length of body. 14th ray when laid back does not reach the upper margin of the caudal base.

A 16, inserted below origin of soft dorsal, shape similar to that of soft dorsal, but rays shorter.

P 11 + 3, 1·0–1·08 times head, 3·0–3·2 in length of body, tip reaches to below the base of the 3rd–5th dorsal ray, and to below the 24th–25th lateral line scale. First upper and lower three of connected rays simple. Longest free ray 1·4 in head, does not reach ventral tip.

Ventrals 1·1–1·2 in head, reach origin of anal or just beyond.

Caudal slightly emarginate, peduncle 1·2–1·4 times eye.

Scales moderate, weakly ctenoid dorsally to level of humeral spine, graduated into cycloid on ventral area (Pl. XIX, B, D, and E). Lateral line scales 58–61, tubes with 3–6 branches, with longest above and below (Pl. XIX, F). Sometimes a few pores on body, most marked ventrally, occasional scales perforated. 23–25 spines along dorsal base. Breast naked.

Colour.—Preserved, uniform red-brown. Inner portion of pectorals dark with light margin above and below.

Length.—35–178 mm.

Locality.—Natal, off Tugela mouth, up to 63 fathoms.

Lepidotrigla multispinosus n. sp.

(Plates XVII and XX.)

Dorsal profile of snout undulate, abruptly descending, concave before eyes, convex on anterior part, with abrupt descent at tip. Depth 4, length of head 3·1 in length of body. Eye 4·0, interorbital 4·8, snout 2·0, postorbital part of head 3·1 in length of head.

Rostrals, with slight, widely diverging, medio-longitudinal ridge, length 11 in head (measured between parallels of mid-point of snout and tip of process). At the apex are small spines, mostly invested; on the left process there are 5 small outer spines and 12 inner, the first (outer)

of the 12 by far the largest: on the right are 10 spines, with the outer longest (Pl. XVII, C). Distance between the apices of the longest rostral spines 3 in head. Lateral keel of preorbital very faint, ending below and not continuous with the preopercular ridge. A distinct ridge on lower margin of preopercle, 1·3 times eye, slightly oblique downwards to the angle, at which there is no spine. Two weak spines above the anterior part of the orbit; one larger above the hind margin. On each side one weak occipital, and two nuchal spines, the hinder the larger: apex of this just reaches the base of the 3rd dorsal spine. Interorbital deeply concave. The granules on the cheek radiate fan-wise backwards from below the front margin of the eye; similarly on the opercle from the base of the spine. On the preorbital the arrangement is irregular. A short deep groove at the supero-posterior margin of the orbit continuous, angularly bent backwards across the occiput. Humeral spine 3, free distal portion 6 in head.

Mouth sub-inferior, lower jaw included, maxilla 2·6 in head. Villiform teeth in bands in both jaws, wider in upper jaw. Vomerine teeth doubtful. None on other bones. Tongue adnate. Large pores on lower surface of mandibles. No barbels. Branchiostegals 7. Membranes free from isthmus. Gill-rakers 5, longest 5 in eye, plus 4 anterior rudiments. Pyloric caeca 6, moderate.

D VIII + 15, inserted above the hind margin of the operculum. 1st spine 2·1, 2nd and 3rd subequal, 1·8 in head. 1st spine with 24 anterior spinules, 2nd and 3rd weakly spinate. Base of 1st dorsal 1·8 in head. Longest soft ray (5th–8th) 3·5 in head. Base of soft dorsal 1·1 times head. On one side 23, on the other 25 spines below the dorsal.

A 16, originates below the origin of the soft dorsal.

P 11 + 3, 1·2 in head, reaches to below the base of the 7th dorsal ray. Longest (upper) free ray, reaches almost to ventral tip, 1·4 in head.

V I, 5, reach to base of 3rd anal ray.

Caudal almost truncate, peduncle twice eye.

Scales (mostly shed) relatively small, ctenoid to below the pectoral base, ventral scales with a single large denticle (Pl. XX, A, B, and C). l.l. 59. Each tube with an upper and a lower oblique branch, and from one to four smaller intermediate branches, each ending in a pore (Pl. XX, D). Breast naked.

Colour.—Preserved, uniform red-brown. Pectorals dark.

Length.—160 mm.

Type in the Albany Museum.

This specimen was among certain fishes presented to the Albany Museum by the Director of the Government Fisheries Survey. It was without serial number or locality, although probably from Natal.

It is very clearly distinct from our other species, the preopercular keel,

the number of the preorbital spines, the long peduncle, the smaller scales, and the relatively short 3rd dorsal spine being distinctive features. This species appears to be well differentiated from all others by several features, notably the deep excavation between the long multidentate preorbital extensions and by the preopercular keel.

Genus Chelidonichthys Kaup.

1925. Barnard, *loc. cit.*, p. 939.

Scales very small. Three free pectoral rays. Palatines edentate. A row of spinose plates along the base of the dorsal fin. Lateral line without spines, bifurcating at the caudal base. Preorbitals produced into spines.

Europe, Africa, Japan, and Australia.

This genus appears to be quite valid, but is apparently not recognised by some systematists.

As far as the South African species are concerned, Barnard's treatment requires no revision, the descriptions being in the main accurate and detailed, and the differentiations clearly defined.

Key to the South African Species.

I. Breast naked. Preorbitals ending in several (usually incurved) spines.
  A. Eye not greater than interorbital width . . . . . . *capensis.*
  B. Eye distinctly greater than interorbital width . . . . . *kumu.*
II. Breast pitted. Preorbital ending in one large straight outer spine, with inner concealed fused spines . . . . *queketti.*

capensis C. and V. appears to be well differentiated from any European species, as indicated by Barnard (*loc. cit.*). This species is of moderate economic significance as a food-fish in South Africa.

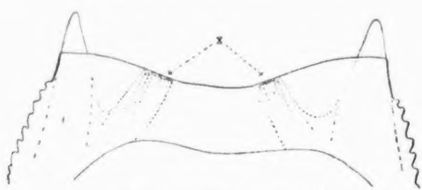


Fig. 1.—Preorbital spines of *Chelidonichthys queketti* Rgn.
X = Inner fused spines, concealed by membrane.

Barnard (*loc. cit.*) has compared our specimens of *kumu* L. and G. with Australian specimens, and his opinion that they are conspecific is here accepted.

queketti Rgn. is apparently an endemic species. Previous workers do not appear to have noticed that, besides the large outer preorbital spine,

there is on each side, concealed within the basal skinny membrane, an inner process, which has obviously been produced by the coalescence of from four to eight smaller spines (fig. 1).

Genus Peristedion Lac.

1895. Goode and Bean, Ocean Ichth., p. 470.
1913. Weber, Siboga Exp. Monogr. 57, p. 511.
1925. Barnard, Ann. S.A. Mus., vol. xxi, p. 944.

Body covered with bony plates, each bearing a spine. Mouth inferior, lower jaw included, with barbels on the lower margin, the outer the longest. Each preorbital greatly enlarged and produced forwards as a spatuliform process, with lateral keel continuous along lower margin of preopercle, which ends in a spine. No teeth. Dorsal single or divided. Two free pectoral rays.

Two species have been found in our area, *adeni* Lloyd, and what has hitherto (though with doubt by Barnard, *loc. cit.*, p. 946) been accepted as *gracile* G. and B. This latter species has now been found not to be conspecific with *gracile*, and is here described as *weberi* n. sp.

Many other species will doubtless be found in our area with more intensive collecting, and it is not unlikely that at least some of the relatively numerous Indo-Pacific forms will be among them.

Key to the South African Species.

I. No spines on dorsal surface of snout. l.l. 34 . . . . . . *weberi*.
II. One median and 4 smaller spines on dorsal surface of snout. l.l. 30 . *adeni*.

Peristedion weberi n. sp.

(Plate XXI.)

1924. Gilchrist and von Bonde, Fish. Mar. Surv. spec. Rep. iii, p. 22 (*gracile*).
1925. Barnard, Ann. S.A. Mus., vol. xxi, p. 945 (*gracile*?).

Dorsal profile abruptly descending before upper half of eye, thereafter slopes more gently. Depth 5·4 (5·0), length of head including rostral process 2·4 (2·1), rostral process 8·5 (7·5) in length of body. (The figure in brackets gives length in distance from base of caudal to tip of maxilla.) Eye 5·5 (4·2), snout 2·9 (2·2), snout plus rostral process 1·6 (1·2), rostral process 3·5 (2·7), interorbital width 6·5 (5·0) in length of head (including rostral process; the figure in brackets is length in length of head without rostral process).

Interorbital deeply concave, supraorbital ridge moderate, terminating

in a flat spine, followed by two retrorse spines. A small serrated suborbital keel terminating in a feeble blunt spinose projection. The widely diverging rostral processes are continued backwards as serrated ridges, each terminating at the angle of the preopercle, hind margin scarcely acute (Pl. XXI, B and C). No nasal or frontal spines. No spine at base of rostral process. Numerous pores on head and along lower edge of mandible. 8–9 groups of bi- or trifid barbels on each side of the lower jaw, longest fimbriate, equal to orbit. (Pl. XXI, A, pencilled in on photograph.)

Maxilla 1·5 times eye. No teeth in jaws or on palate. Tongue adnate. Gill-rakers 20, longest 2·5 in eye. 30 spinose plates on dorsal, 28 on ventral surface. The anterior ventral plates are 2·3 times as long as broad, *i.e.* the width of the two plates is 1·15 in the length of one plate (Pl. XXI, D). A rectangular portion of the second plates, five times wider than long, fits into a recess in the anterior plates.

D VIII, 20, originates an eye-diameter behind eye, above the hind margin of the operculum. 4th spine longest. 1st spine 3·5, 2nd and 3rd subequal 3·2, 4th 2·9 in length of head (without rostral process). 1st ray 5·4, 2nd 4·3, 3rd 3·6, 4th–8th longest 3·2 in length of head (without rostral process); thereafter the rays decrease.

A 20 (or I, 19), inserted below the base of the 4th dorsal ray. Shape and length of rays as in dorsal. Base of anal 5·6 times longitudinal diameter of eye.

P 11 + 2, 2·2, longer detached ray 1·6, lower 1·8 in head (without rostral process). Upper detached ray reaches well beyond ventral tip. Ventrals 1·9 in head (without rostral process) reach to vent. Membrane for half-length of last ray joined to body.

Caudal emarginate, mid-rays 1·1 times eye.

The lateral line descends abruptly from the shoulder to the middle of the side. 34 spinose plates in the lateral line, 4 of these on the downward portion. Lateral line tubes bifurcate, ending in a pore above and a pore below the spine (Pl. XXI, E). The spines on the anterior 23 plates are simple, those on the 11 posterior plates have an anterior antrorse and a posterior retrorse point (Pl. XXI, E).

Colour.—Preserved, uniform light brown. Traces of dark mottling on distal half of pectoral.

Length.—185 mm.

Locality.—Off Delagoa Bay, in 260 fathoms.

Type in the Albany Museum.

A single specimen, labelled *P. gracile* G. and B., presented to the Albany Museum by the Director of Fisheries Survey.

According to the Fisheries Survey records (Mar. Bio. Rep., 1921 (2), p. 10), 8 specimens, subsequently identified as *Peristedion gracile* G. and B.

(Gilchrist and von Bonde, Mar. Bio. Rep., 1924, iii, p. 22), were obtained off Delagoa Bay, in 260 fathoms; the specimen described above was one of these.

Barnard (*loc. cit.*, p. 947) was very doubtful of the validity of this identification, chiefly because *gracile* is a Mexican species. This has led me to make a critical examination of the specimen in the Albany Museum.

The original description of *gracile* (Goode and Bean, Ocean. Ichth., 1896, p. 473, fig. 387) is based upon a single type specimen about 125 mm. in length. (There are several discrepancies in this description.)

Although reasonably close to *gracile*, the specimen described above is evidently not conspecific. The shape of the spinous dorsal, the longer anal base, the bispinose posterior lateral line plates, and the number of plates, as well as the ridge below the eye, all distinguish the present specimen from *gracile*. There are also fewer gill-rakers, but Goode and Bean may possibly have given the number (26) on the whole arch. The original description of *gracile* does not say whether the rostral processes are divergent, but the two species have much in common. This is another case of remarkably close relationship between Indo-Pacific and Atlantic species.

weberi is also related to *rivers-andersoni* Alcock, and to *nierstraszi* Weber, from the Indo-Pacific. I have seen only the original description and figures of the former species (Alcock, 1894, J. Asiat. Soc. Bengal, lxiii, pt. 2, p. 12, pl. vi, figs. 2, 2*a*, 2*b*). Dr. de Beaufort of Amsterdam has kindly lent me one of the co-types of the latter species. An examination of this indicates that *nierstraszi* is of doubtful validity, since the specimen agrees in most particulars with the description of *rivers-andersoni*, especially if the difference in size between the types of the two species be taken into account, *e.g.* the posterior lateral line plates of this specimen of *nierstraszi* are bispinose, and there is a small but distinct spine on the dorsal surface of the base of each rostral process.

Since I have not seen a specimen of *rivers-andersoni*, I cannot venture to state that *nierstraszi* is conspecific, although it appears quite possible.

In any case *weberi* is quite definitely distinct from either, in the nature of the more slender and diverging rostral processes alone.

In regard to *gracile*, it would not indeed be surprising if a re-examination of that species showed that *weberi* is even more closely related than appears here. It is highly probable that *gracile* actually has bispinose posterior lateral line plates.

Peristedion adeni Lloyd.

(Plate XXII.)

1907. Lloyd, Rec. Ind. Mus., vol. i, p. 8.
1908. Alcock, Illustr. Zool. Invest. Fishes, pl. xliii, figs. 1, 1*a*.

1922. Gilchrist, Fish. Mar. Surv. Spec. Rep. iii, p. 78.
1925. Barnard, *loc. cit.*, p. 945.
? 1925. Fowler, Proc. Ac. Nat. Sci. Phil., vol. lxxvii, p. 256.

Dorsal profile of snout gently sloping before eye, scarcely concave. Depth 5·1, length of head (without rostral process) 2·6, (with rostral process) 2·2 in length of body (without rostral process). Eye 5·5, interorbital width 4·7, snout (with rostral process) 1·4, (without rostral process) 1·7, rostral process (broken) about 6 in length of head (excluding rostral process).

Interorbital moderately concave, supraorbital ridges moderate, with a moderate spine on the posterior margin. On each side of the nape a large spine, and a smaller one below. One median frontal spine. On each side one small antorbital and one small nasal spine. The preorbital process is large, flattened, with inner edges subparallel, outer margins converging; the outer margins produced meet at an angle of 30°. Width of process at base 1·2 in eye. The lateral edge of the preorbital process is continued backwards as an undulate keel, terminating in the large preopercular spine (Pl. XXII, B). There is a short and narrow suborbital keel.

Mouth large, maxilla 2·2 times eye. No teeth, tongue adnate. On each side of the lower jaw there are 7–8 single small barbels, and one large outer, fimbriate, 2·8 times eye. Gill-rakers 17, longest 3 in eye, anterior rakers short but graduated.

21 spinose plates on ventral, 24 on dorsal surface. The anterior ventral plates are together 1·1 times wider than the length, *i.e.* each plate is 1·8 times longer than wide (Pl. XXII, C). 2nd plates each slightly wider than long. A quadrangular portion of the 2nd plates, five times wider than long, fits into a recess in the anterior plates.

D VII + 15, inserted above hind margin of opercle, 3rd spine longest, 3·1 in head (without rostral process). 18 spinose plates along base.

A 15, inserted below the base of the 2nd dorsal ray, base five times longitudinal diameter of eye.

P 11 + 2, 1·9, upper detached ray 2·6 in head (without rostral process). Tip of pectorals reaches to below the 11th lateral line plate.

Ventrals 2·0 in head (without rostral process), just reach vent. Membrane joined to body.

Caudal damaged.

The lateral line descends abruptly from the shoulder to the middle of the side. 30 lateral line plates, 5 of these on the downward portion. The anterior 20 unispinose, the next 7 bispinose, and the last 3 unispinose (Pl. XXII, D). The lateral line pores do not show externally.

Colour.—Preserved, uniform light brown, pectorals darker.

Length.—About 225 mm.

Locality.—Natal.

A single specimen (S.A.M., No. 16223, from Mr. Bell Marley).

The specimen described above was identified as *adeni* Lloyd by Dr. Barnard (*loc. cit.*), with which identification I am provisionally in agreement.

There are, however, certain variations from the original diagnosis, the most marked of which is the presence of the mid-posterior bispinose lateral line plates. These are not as obvious as in the species (*weberi*) previously described, and may have escaped notice.

The original description makes no mention of the antorbital and nasal spines. Barnard (*loc. cit.*) mentions these, but does not draw attention to the fact that they were not present in the type diagnosis.

In this specimen the outer margins of the preorbital processes would meet at a more acute angle than those of the type, *i.e.* they are less markedly convergent, but this feature is not of importance, and might vary considerably. Further, there is no mention of the suborbital keel which is present in this specimen.

These combined differences might, if established, justify the separation of the present specimen from *adeni*, but as I have not access to any type of that species, it would be unwise to venture this step.

Genus TRIGLA Art.

1925. Barnard, *loc. cit.*, p. 943.

Body covered with very small scales, ctenoid above, cycloid on ventral surface. Three free pectoral rays. Lateral line scales spinose. A row of spinose plates along the base of the dorsal fin. No palatine teeth. Lateral line bifurcates at the caudal base.

Trigloporus new sub-genus.

Distinguished from *Trigla* (*sensu stricto*) by the whole body (excepting the chest) being covered with a complex system of reticulate tubes (each ending in a pore), between rectilinear transverse multiporose tubes, as well as by the multispinate nature of the lateral line scales. The pectorals are also probably longer than in *Trigla* (*Trigla*).

Europe and Africa.

Genotype, *africana* n. sp.

This sub-genus is proposed with considerable doubt as to its validity, since I have seen, besides *lineata* Gmel., only one other European species of *Trigla* (*sensu lato*), viz. *gurnardus* Linn. The extraordinarily highly developed mucus canal system of *lineata* and of *africana* (which are clearly congeneric in all respects), as well as the spination of the lateral line scales, would appear to justify full generic distinction of the latter two species

from *gurnardus*. Against this, however, is an account of the species of *Trigla* by Smitt (Skand. Fish., 1892, pt. 1, p. 191), of which I have seen a brief abstract, in which he states that the species of this genus show practically all stages of development of the mucus canal system intermediate between that of *gurnardus* and that of *lineata*. Despite this, the difference between these species is very striking, but since material to establish or refute the absolute accuracy of Smitt's statement is not available, as a compromise, *Trigloporus* is proposed as a sub-genus of *Trigla*.

Trigla (*Trigloporus*) *africana* n. sp.

(Plate XXIII.)

1925. Barnard, *loc. cit.*, p. 943 (*lineata* Gmel.).

Dorsal profile of snout fairly steep, gently concave. Depth 4·5–5, length of head 3·5–3·7 in length of body. Eye 4·3–4·5, interorbital 4·0–4·5, snout 2·2, postorbital part of head 2·5, preorbital depth 2·4–2·5 in length of head (measured from the hind edge of the operculum at the spine to the snout tip). Front of snout rounded, or with slight median concavity. The preorbitals are not produced, and there are no obvious spinules. Interorbital deeply concave. Two to four backwardly radiating antero-supraorbital ridges, each ending above the orbital margin in a small spine. One to three minute supero-postorbital spinate ridges, without any cross groove behind. One to three nuchal spines, the infero-posterior the longest, just reaches below the base of the 1st dorsal spine. Humeral spine very short, apex reaches beyond the hind margin of the operculum, a distance equal to 5·5–6·2 in head. No keel on preorbital, the lower edge of which is scarcely serrate. One set of backwardly radiating granules from anterior margin of preorbitals; three radiating sets on cheek, lower above end of maxilla, median largest in centre of cheek, and a smaller group below hind margin of eye. Preopercular and opercular spines very feeble.

Maxilla extends to below the hind margin of the eye. No vomerine teeth. The pores on the lower surface of the rami are arranged in 5–6 more or less regular longitudinal series, close set, but not aggregated into groups.

D X + 15–16, inserted above slightly in advance of hind margin of operculum. 1st spine 1·4–1·5, 2nd, longest, 1·3–1·4, 3rd 1·4–1·5 in head. 1st spine with a few rudimentary spinules or granules on the lower anterior edge. Soft rays 2·5 in head.

A 15–16, inserted below the soft dorsal, rays similar to dorsal.

Pectorals 1·25–1·3 times head; tip reaches to below the 4th–5th dorsal

ray. Longest free ray 1·1–1·2 in head, tip reaches to the posterior third of the ventral.

Ventrals 1·0–1·2 times head, reach to the base of the 2nd–4th anal ray.

Scales very small, strongly ctenoid above the lateral line (Pl. XXIII, C), grade into cycloid on ventral surface. The whole of the body is covered with the reticulate system of mucus canals described earlier, the transverse rectilinear tubes resembling lateral folds of the skin between the scale rows (Pl. XXIII, B). 67–70 scales in the lateral line, each scale bearing 2–5 spines, each much smaller than the single spine on the lateral line scales of the species *gurnardus* Linn. Breast partly or wholly scaly.

Gill-rakers 7–8. Pyloric caeca 7–9.

Colour.—Red-brown, mottled and spotted, with 4–7 faint cross-bars. Spinous and soft dorsal and caudal with irregular blotches. Ventrals reddish. Pectorals bluish, with irregular cross-mottlings; free rays with several brownish blotches.

Length.—Up to 230 mm.

Localities.—Cape St. Blaize, 26–33 fathoms; Algoa Bay, 40 fathoms; Port Alfred, cast up on the shore.

Holotype, from Port Alfred, in the Albany Museum.

The South African specimens have hitherto been regarded as identical with the European species *lineata* Gmelin.

Since I had access to no recent detailed descriptions of that species, I forwarded a specimen of our species to Mr. Norman of the British Museum, requesting him to compare it with the European form, and, if there appeared any doubt of conspecificity, to send me material for comparison. He has kindly sent this, and there appears to be little doubt that the South African species is well differentiated.

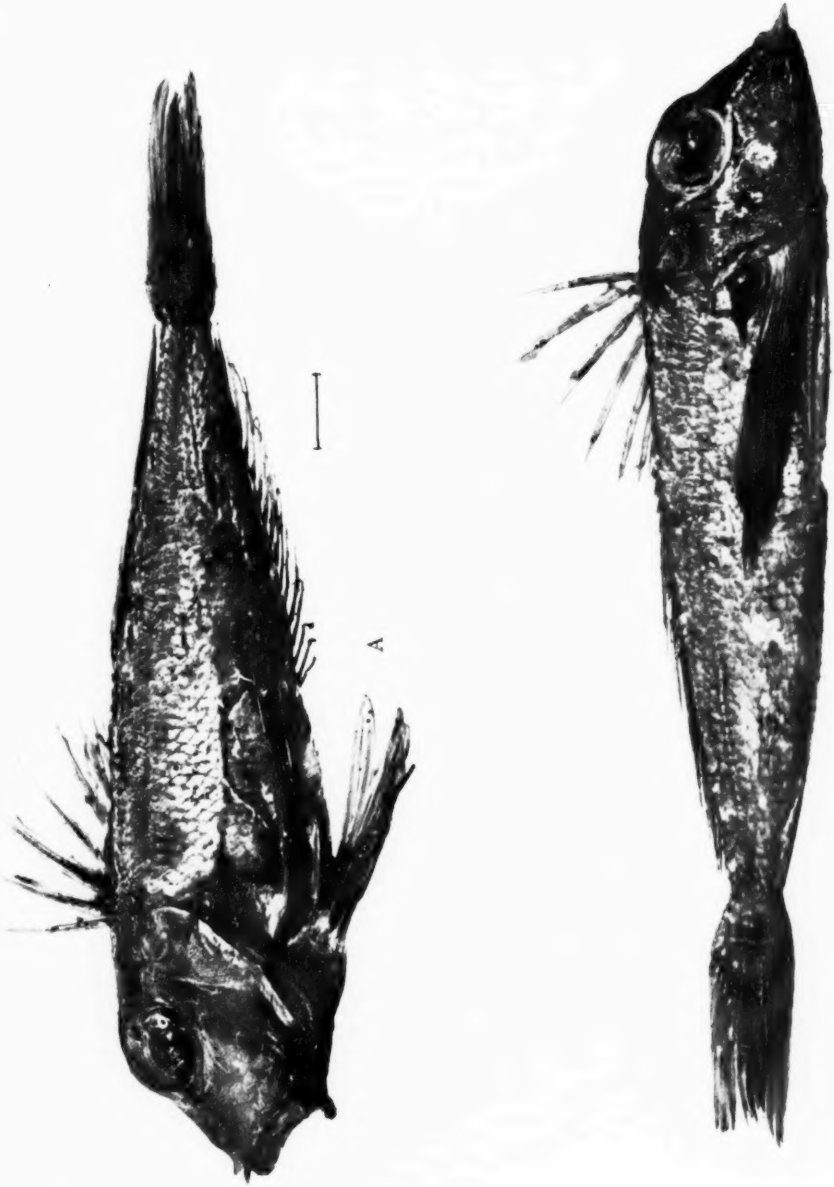
The following table indicates some of the numerous features by which the two species are differentiated:—

	lineata	*africana.*
Pectoral times head	1·6	1·2–1·3
Humeral spine in head	3·4	5·5–6·2
Eye in head	3·4	4·3–4·5
Pores on rami	In groups of 5–6	In uniform rows
Breast	Naked	Scaly
Lower margin of preorbitals . .	Serrate	Smooth
Dorsal spines	12	10
Anterior margin of first dorsal spine	Serrate whole length	Feebly serrate basally

Besides these, the dorsal profile of the snout of *lineata* is much steeper, and the angle subtended by the corners of the mouth at the symphysis is much less than in our species, while the spination and granulations on the head of *lineata* are much more marked than in *africana*, and the spinous dorsal is markedly larger.

I wish to express my gratitude to Dr. Barnard, Assistant Director of the South African Museum, for the very considerable assistance he continually affords me in providing extracts from literature not available here, as well as for freely lending material from the South African Museum collection. Also to the Carnegie Research Fund, through the Research Grant Board of South Africa, for generous financial assistance.

ALBANY MUSEUM,
GRAHAMSTOWN,
June 1934.



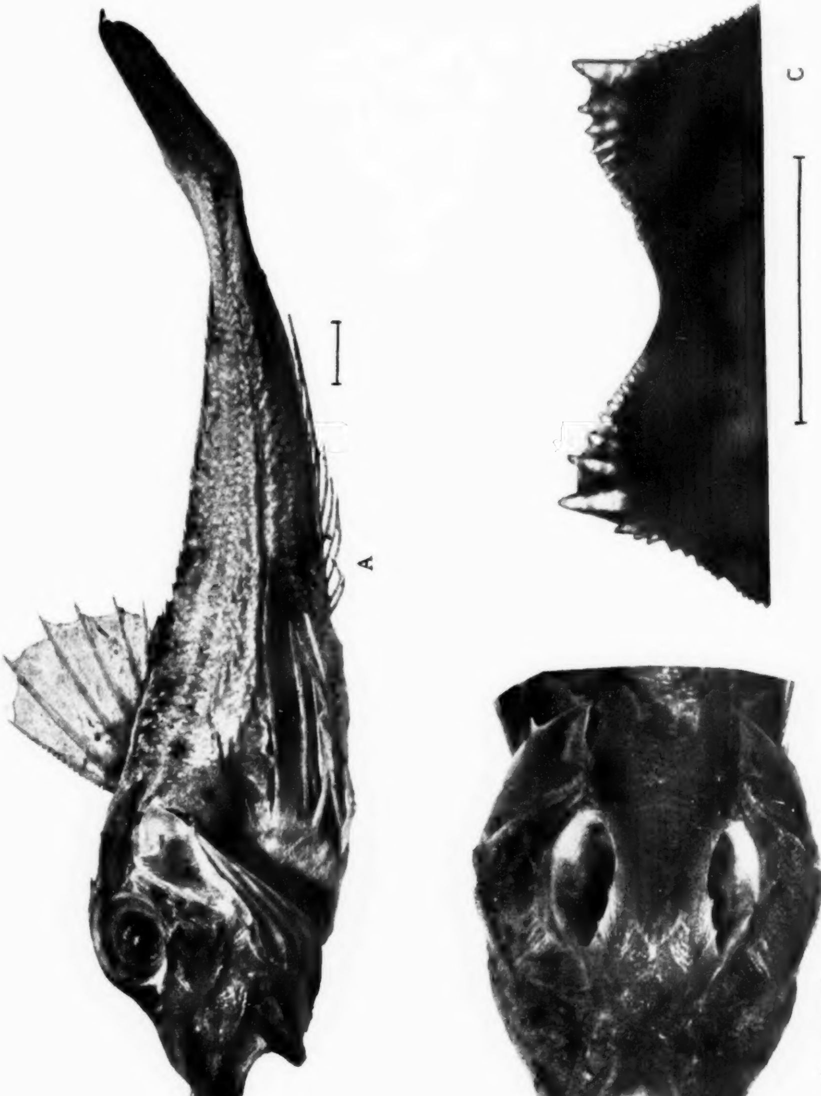
A. *Lepidotrigla faurei* G. and T. B. *Lepidotrigla natalensis* G. and T.

The line below each figure represents 1 cm.

J. L. B. Smith.

Neill & Co., Ltd.

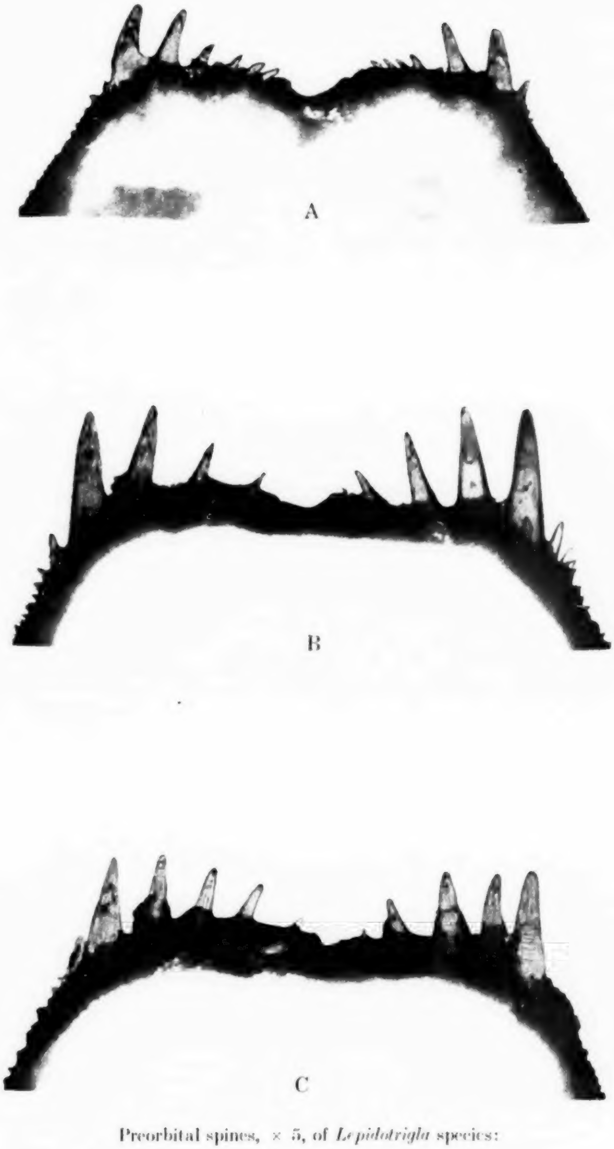
Tr



A. *Lepidotrigla multispinosus* n. sp. (Type.) B. Dorsal view of head. C. Preorbital spines.
The line below each figure represents 1 cm.

J. L. B. Smith.

Neill & Co., Ltd.

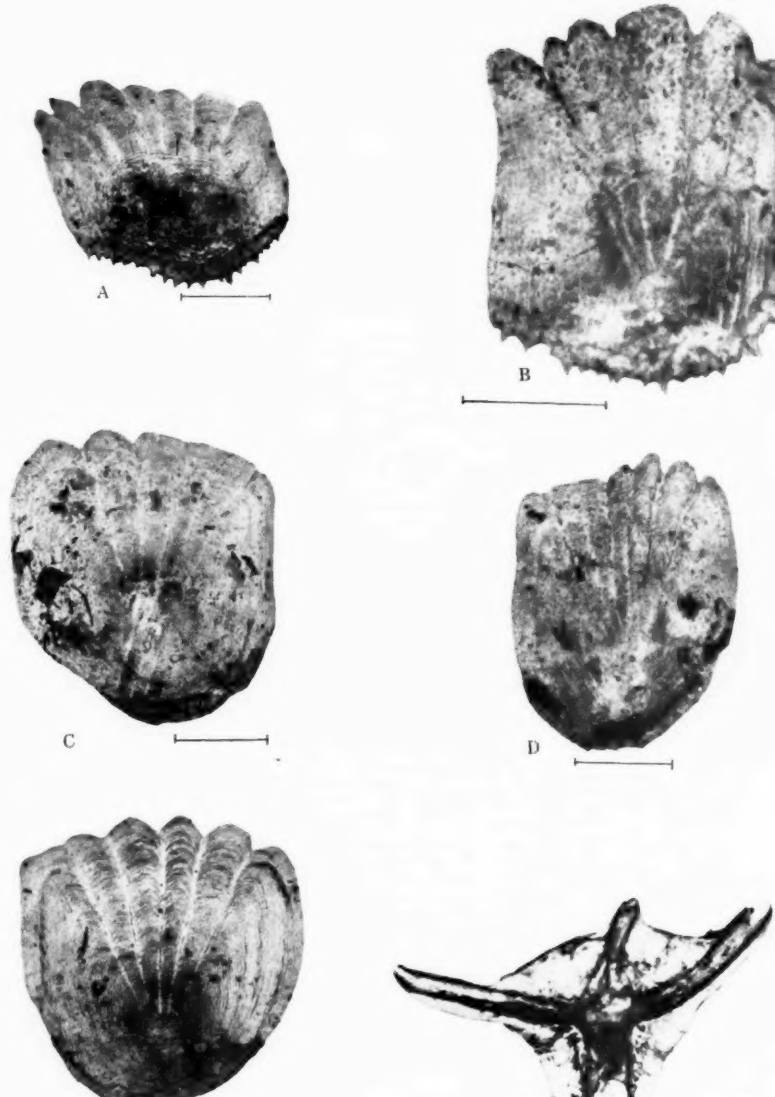


Preorbital spines, × 5, of *Lepidotrigla* species:

A. *faurei* G. and T.

B and C. *natalensis* G. and T., showing limits of variation.

J. L. B. Smith. Neill & Co., Ltd.



Scales of *Lepidotrigla* species:

A. Above lateral line, below spinous dorsal, of *fauri* G. and T.

B. Equivalent scale of *natalensis* G. and T.

C. Ventral, behind breast, of *fauri* G. and T.

D. Equivalent scale of *natalensis* G. and T.

E. From behind pectoral base of *natalensis* G. and T.

F. 31st lateral line scale of same.

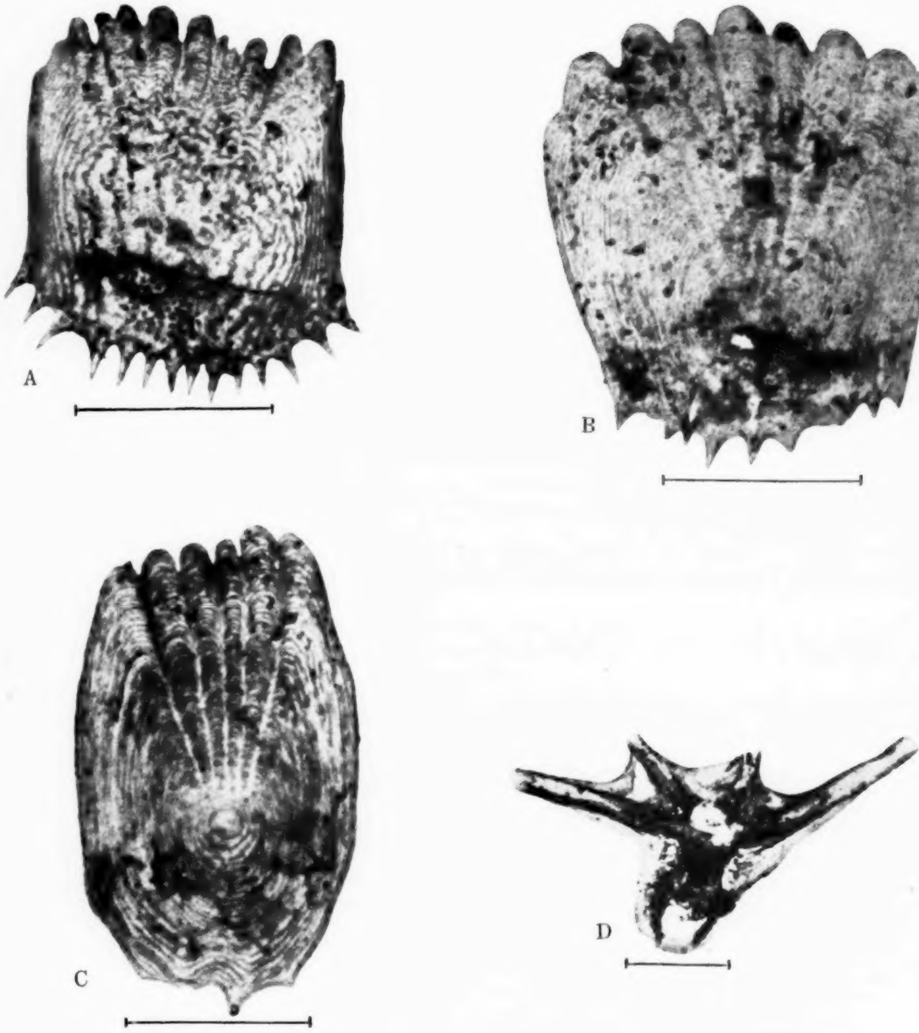
The line below each scale represents 1 mm.

J. L. B. Smith. Neill & Co., Ltd.

Tra

A

J.

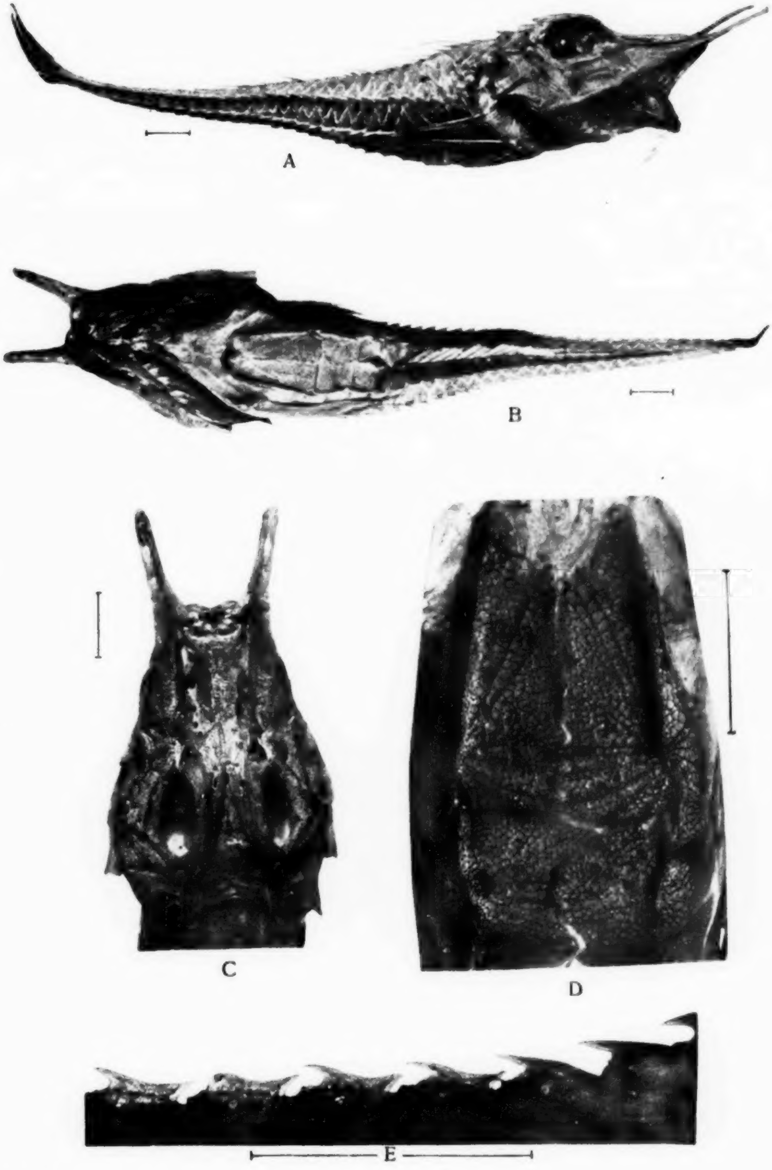


Scales of *Lepidotrigla multispinosus* n. sp.

A. Above lateral line, below spinous dorsal.
B. Behind pectoral base.
C. Ventral, behind breast.
D. 30th lateral line scale.

The line below each scale represents 1 mm.

J. L. B. Smith. Neill & Co., Ltd.

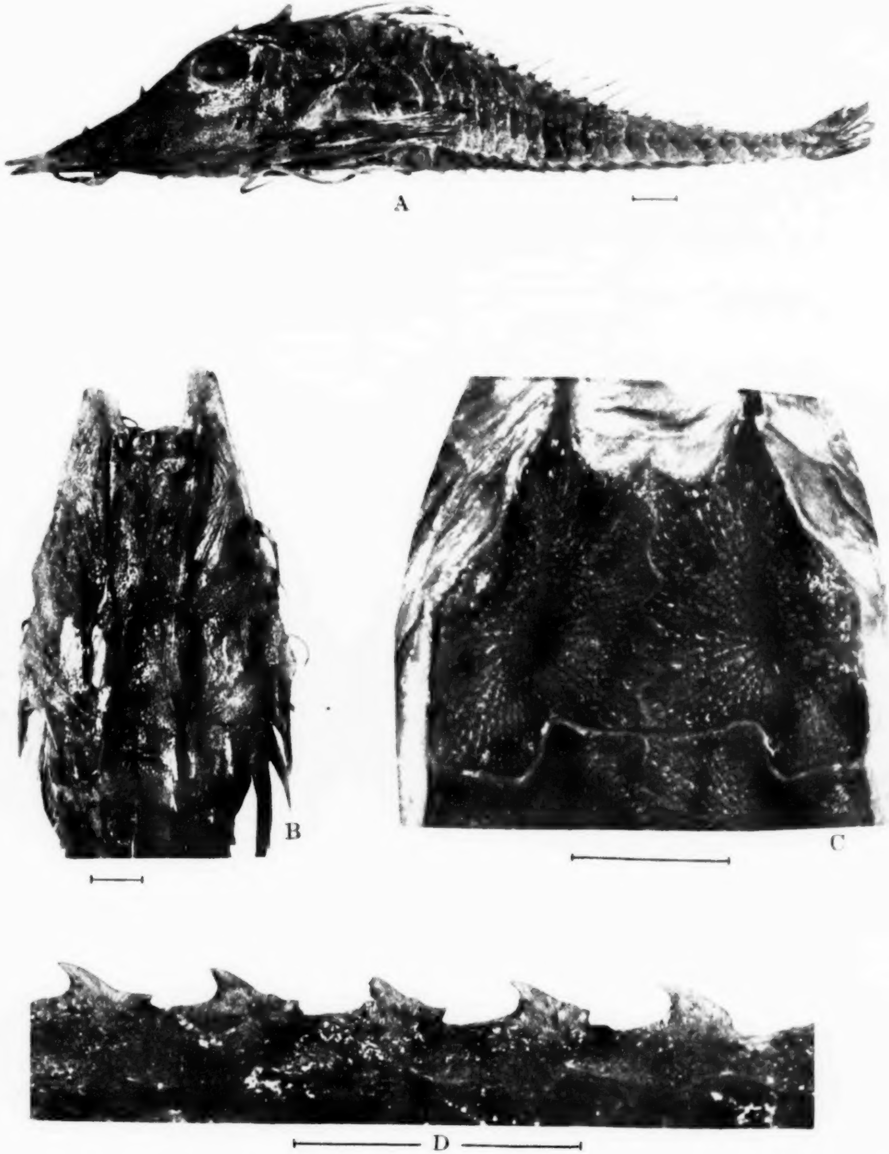


A. *Peristedion weberi* n. sp. (Type.)
B. Ventral surface.
C. Dorsal view of head.
D. Anterior ventral plates.
E. 21st (right) 27th lateral line spines from above.
The line with each figure represents 1 cm.

J. L. B. Smith. *Neill & Co., Ltd.*

Tra

J.

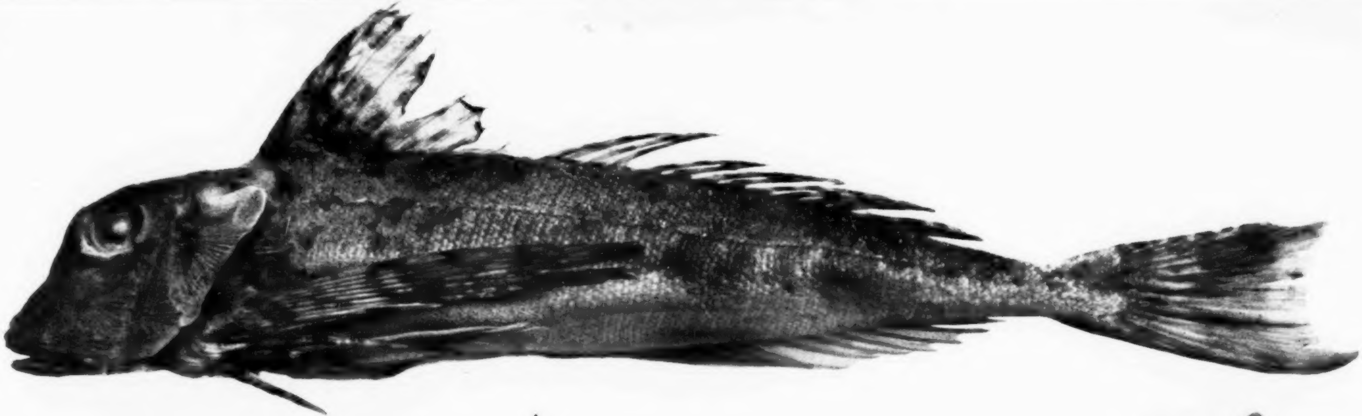


A. *Peristedion adeni* Lloyd.
B. Dorsal view of head.
C. Anterior ventral plates.
D. 20th (right) 24th lateral line spines from above.

The line below each figure represents 1 cm.

Trans.

J. L. B.



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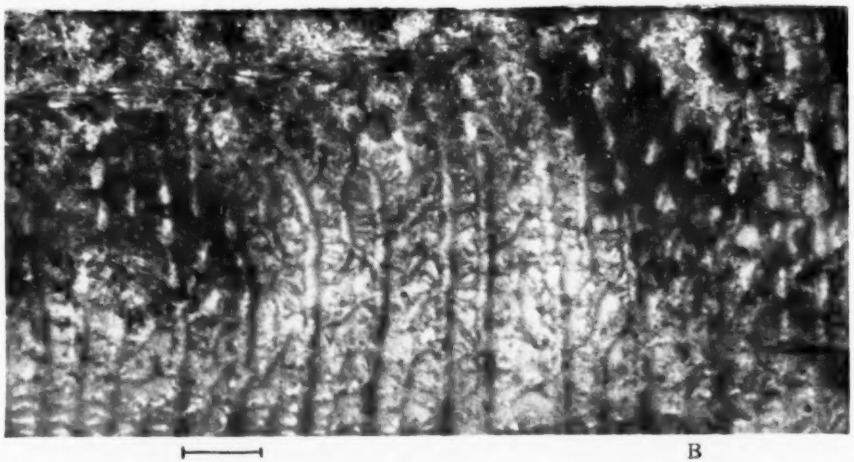

B

C

A. *Trigla* (*Triglopurus*) *africana* n. sp. Nat. size. (Type.)
C. Scale from below the spinous dorsal, above the lateral line.

B. A portion of the skin below the lateral line, showing a few lateral line scales.
The line below B and below C represents 1 mm.

J. L. B. Smith. Neill & Co. Ltd.

TRANSACTIONS

OF THE

ROYAL SOCIETY OF SOUTH AFRICA.

VOL. XXII.

MINUTES OF PROCEEDINGS.

ANNIVERSARY MEETING.

The Anniversary Meeting of the Society was held on Wednesday, March 20, 1929, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. W. A. JOLLY, was in the Chair.

The Reports of the Hon. General Secretary and the Hon. General Treasurer were adopted, and a vote of thanks to the auditors, Professor B. J. RYRIE and Professor W. N. ROSEVEARE, was approved.

The President announced that as the result of the ballot the Council's nominees of Officers and Members of Council for 1929 had been elected :—

President, Dr. W. A. JOLLY; Hon. Treasurer, Dr. L. CRAWFORD; Hon. Secretary, Dr. B. F. J. SCHONLAND; Members of Council, Dr. R. S. ADAMSON, Dr. C. W. MALLEY, Dr. H. SPENCER JONES, Dr. C. F. JURITZ, Dr. A. OGG, Professor H. H. PAINE, Mr. C. M. STEWART, Dr. J. SMEATH THOMAS, Dr. R. B. YOUNG.

The President made reference to the loss sustained by the Society in the death of Sir WILLIAM TURNER THISTLETON-DYER, K.C.M.G., F.R.S., an Honorary Fellow of the Royal Society of South Africa, and gave a short résumé of his career. He was born in July 1843, and died in December 1928. He was educated at King's College, London, and Christ Church College, Oxford. After holding appointments as a Professor of Natural History at the Royal Agricultural College, Cirencester, Professor of Botany at the Royal College of Science, Dublin, and at the Royal Horticultural Society, London, and acting as assistant to Professor Huxley at South

Kensington, he was appointed Assistant Director of Kew under Sir J. D. HOOKER, and afterwards Director of Kew, from 1885–1905, when he retired. He was elected a Fellow of the Royal Society in 1880, and was Vice-President 1896–1897. He was President of Section D of the British Association in 1888, and first President of the new Section K in 1895. He contributed largely to botanical literature, was joint author of Flora of Middlesex, instituted the Kew Bulletin in 1887, editor of Flora Capensis, Flora of Tropical Africa, and Flora of British India.

During his period at Kew the Herbarium doubled in size, the Alpine House was inaugurated, and the Winter Garden completed.

He also carried out classical studies, and made many contributions to the new edition of Liddell and Scott's Lexicon, etc.

The Honorary Treasurer gave a short sketch of the career of the late Dr. H. BRAUNS.

Dr. H. BRAUNS, M.D., Ph.D., D.Sc., was born at Hanover in 1857, came to South Africa in 1895, and practised at Port Elizabeth, later at Bothaville, and from 1899 at Willowmore. He died on February 3, 1929.

Dr. BRAUNS collected extensively, and his collection of South African Hymenoptera, now housed in the Transvaal Museum, is the richest in South Africa. His chief papers dealt with the families Aphidae, Aphegidae, Masaridae, and Chrysididae, and were published mainly in the Deutsche Entomologische Zeitschrift, Entomologische Mitteilungen, and other continental periodicals, but some appeared in the Annals of the South African Museum and the Annals of the Transvaal Museum.

The honorary degree of D.Sc. was conferred upon him in 1928 by the University of Stellenbosch.

ORDINARY MEETING.

The Anniversary Meeting was followed by an Ordinary Meeting.

Business:—

The Minutes of the Meeting of October 17, 1928, were confirmed.

CECIL GORDON, M.Sc., DAVID SLOME, M.A., and Dr. J. H. FERGUSON were elected Members.

It was resolved to ask the Council to consider the purchase of an epidiascope for the use of authors when bringing their communications before the Society.

Communications:—

"Colour and Chemical Constitution, Part XXVI. (A) Pigments of Yellow Flowers. (B) Addenda to Previous Parts," by JAMES MOIR.

"Note on the Lagrangian of a Special Unit Determinant," by Sir THOMAS MUIR, F.R.S.

"Notes on the Karroo Reptilia from Madagascar," by S. H. HAUGHTON.

"A Study of the Genus *Colophon* (Coleoptera)," by K. H. BARNARD.

"The South African Species of *Rhus* L.," by S. SCHONLAND.

Except for the publication in 1859–1860 of the first volume of Harvey and Sonder's Flora Capensis, no general account of the South African species of *Rhus* has been readily available for South African students. In 1883, Engler included our species in his monograph of "Anacardiaceae" (in De Candolle, Monographiae Phanerogamarum, vol. iv), but, except for some Natal and Transvaal species, he based his account largely on the same material which Sonder used. Since then the material available for study has enormously increased, a number of new species have been described in scattered publications, and the sharp divisions between many of the older species have become obliterated. The author, in addition to extensive field studies, has seen a large amount of material preserved in South African herbaria, and has also had the advantage of examining the material of the herbaria at Kew, the British Museum, the Linnean Society, and at Berlin-Dahlem. He had also the loan of the species of *Rhus* preserved in Thunberg's herbarium at Upsala, and of Jacquin's herbarium preserved at Vienna.

There is comparatively little diversity in the flowers of *Rhus*. Inflorescences and fruits yield distinctive characters in many cases, but on the whole one has to rely on vegetative organs which, however, vary often on the same plant within wide limits. The plants are usually unisexual, and male and female plants are sometimes different. Further, coppice shoots often show distinctive features. The taxonomy of the genus presents, therefore, unusual difficulties, which the author cannot pretend to have completely overcome. These difficulties are increased by the fact that interspecific hybridisation is not uncommon.

The subject has been divided as follows:—

Introduction with brief historical notes. Distribution. Habit. Leaves. Inflorescences. Flowers. Fruits. Uses. The phylogeny of South African species.

Division into 12 groups with their characters, distribution, and keys to the species.

Description of the species with notes on distribution, relationships, hybridisation (if any), etc. Enumeration of most of the material examined.

Sketches of leaves of all species are added to the description and notes.

"Contributions to our Knowledge of the Freshwater Algae of Africa. 8. Bacillariales (Diatoms) from Griqualand West," by F. E. FRITSCH and FLORENCE RICH (communicated by Miss E. L. STEPHENS).

B. F. J. SCHONLAND,
Hon. General Secretary.

An Ordinary Meeting of the Society was held on Wednesday, April 17, 1929, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. W. A. Jolly, was in the Chair.

Business:—

The Minutes of the Anniversary Meeting and of the Ordinary Meeting held on March 20, 1929, were approved.

On the motion of Professor L. Crawford, seconded by Professor A. Ogg, J. H. Dobson, D.S.O., D.Eng., M.Sc., was nominated for Membership.

The President, followed by Dr. C. F. Juritz and Professor Ogg, made reference to the death of Dr. James Moir, a foundation Fellow of the Society, a Vice-President in 1911, and on several occasions a Member of Council.

Dr. Moir was born at Banff, Scotland, in 1874, and died in Johannesburg on April 1, 1929. He was the son of Dr. James Moir, Rector of Aberdeen Grammar School, a distinguished classical scholar and renowned head-master. Dr. Moir graduated M.A. and B.Sc. at Aberdeen University in 1897, with first-class honours in Mathematics, Natural Philosophy, and Chemistry.

He acted as research assistant to Professor F. R. Japp, F.R.S., at Aberdeen University until 1900, when he was appointed to an 1851 Exhibition Science Scholarship. He continued his research work in London at the City and Guilds Central Technical College, and was awarded the D.Sc. degree by Aberdeen University.

He came to South Africa in 1902, taught for a short time at Jeppe High School, and was appointed chemist to Messrs. H. Eckstein & Co., who opened the Rand Mines Laboratory in 1903. In the following year he was appointed to the Transvaal Mines Department, and continued in this office after Union. Dr. Moir was twice elected President of the South African Chemical Institute, and President of Section "B" of the South African Association for the Advancement of Science, from which he received the South African Medal in 1919.

Dr. Moir was an assiduous research worker, especially in inorganic chemistry, and published over 100 contributions to various scientific subjects.

His publications in the Transactions of this Society were on "Colour and Chemical Constitution," of which Part XXV is now in the Press, and Part XXVI was read at the March Meeting.

He carried on his work with great enthusiasm despite the fact that he was often in very bad health. By his death South Africa has lost one of its most distinguished chemists.

Communications:—

1. "Some Derivatives of Thiazole," by J. L. B. Smith and R. H. Shapiro.

2. "Report on the Natural History of Pans and other Fresh Waters of the Transvaal," by G. E. Hutchinson, G. E. Pickford, and J. F. M. Schuurman (communicated by Dr. L. Gill).

3. "New and Noteworthy Mosses from South Africa," by H. N. Dixon and H. A. Wager (communicated by V. A. Wager).

4. "Thunderstorms and the Penetrating Rays," by B. F. J. Schonland.

A preliminary account was given of a new apparatus devised by the author for the study of the penetrating radiation, and of investigations made with it under thunderstorms at Somerset East in January and February 1929.

The main feature of the instrument, which is being fully described elsewhere, is an electroscope in which the moving part is a very light mica mirror suspended by two fine strips of gold leaf. The sensitivity of the arrangement is considerably greater than that of any hitherto employed.

Measurements of the intensity of the penetrating radiation underneath five active thunderstorms did not differ appreciably from measurements made during periods of fine weather. The observations will be continued to examine whether a more localised effect is present.

A short account was given of the present position with regard to this radiation and of the possibilities of its being corpuscular in nature and arising from thunderstorms, as suggested by C. T. R. Wilson.

5. "On Recording Lymph-heart Beats," by W. A. Jolly.

The work was undertaken with the object of studying the action of the lymph-hearts in Anura when the conditions are as nearly as possible normal. It was desired to avoid the use of anaesthetics and to obviate the need for any operative procedure at the time when the beats are recorded. The animal selected was Xenopus. It is impracticable in an intact animal to secure such quiescence as is necessary for registering the beats of the lymph-hearts, and recourse was had to the chronic spinal preparation. The spinal cord is transsected under anaesthesia, and the wound is allowed to heal completely. The hind limbs are in this way paralysed for voluntary movement, and registering is rendered possible.

The skin over each posterior lymph-heart moves with the beats, and advantage is taken of this to record the lymph-cardiogram without incising the skin. The method employed is that of the optical lever. A minute fragment of silvered cover-glass is placed on the skin—to which it adheres—where the impulse is most distinct, and a beam of light reflected from this mirror is focussed on the slit of a photographic recorder furnished with a roll of sensitised paper.

The beat of the lymph-heart recorded in this way is remarkably regular.

The record is that of a twitch with simple ascent and descent, and the differences in amplitude of systole and duration of diastole between successive beats are, as a rule, small. The extra-systoles described by previous observers (*cf.* v. Brücke, Pflügers Archiv, 115, 1906, p. 334) are not conspicuous features of the curve, and it may be doubted whether they occur in the entirely normal organ. Measurements made when the gullet temperature of the animal was 16·5° C. give values of about $\frac{2}{10}$th second for the ascent and about $\frac{3}{10}$th second for the descent of the curve.

The effect of temperature on the rate of beat has not been studied by altering the animal's temperature artificially, but the rate has been recorded in the same animal from day to day as the weather changed and the animal became adapted to the room temperature. In one animal at a gullet temperature of 16·5° C. the rate was found to be 56·4 per minute, and 5 days later, when the gullet temperature was the same, the rate was 56·2 per minute; on the following day, when the weather had changed and the gullet temperature was 20·5° C., the rate of lymph-heart beat was found to be 75 per minute.

In some experiments the electrocardiogram of the systemic heart was recorded simultaneously with the beat of the lymph heart, and a relation between the rates of the two organs was sought for. While further observations are necessary the following are of interest: At 16·5° C. with the lymph-heart beating at 56·2 per minute the systemic heart rate was 21·4 per minute, giving a ratio of 1 to 2·63. At 20·5° C. the lymph-heart rate was 75 and the systemic heart rate was 28·2, giving a ratio of 1 to 2·66.

The lymph-heart's action is not continuous, but shows periods when the beat becomes very small or ceases altogether. This phenomenon has been described by previous observers. v. Brücke, who used anaesthetised animals and incised the skin, records the occurrence of such periods of quiescence, but he is inclined to take the view that they are due to some external cause, such as manipulation of the organ or struggling movements of the animal. The results of the present investigation, in which external interference may be regarded as absent, would suggest that temporary stoppages are a normal feature. The beats may decline in a staircase manner or cease abruptly. In one record there is complete cessation for 17 seconds, except that a few very small beats occurred towards the end of the pause; the record showed a declining staircase with progressive diminution in amplitude of the beats and increase in the diastolic interval. The last diastolic interval before cessation exceeded the penultimate interval by 45 per cent. When the beat recommenced it did so in a staircase manner. During a period of cessation the effect of the systemic pulse may be just visible on the record.

These records from the skin also give evidence of another rhythmical

phenomenon. At fairly regular intervals the curve is interrupted by a series of small rapid oscillations. These are due to contractions of the thoracic and abdominal muscles. These interruptions have been recorded at rates of from 3 to 5 per minute, and their frequency seems to depend upon whether the animal has previously been struggling or not. When the animal remains completely quiescent for a time the movements become infrequent and seem to cease altogether. The oscillations themselves, of which there may be 4 or 5 in a series, occur at a rate of 2·5 per second at 16·5° C. and 2·9 per second at 20·5° C. It seems probable that these muscular contractions are accessory respiratory movements.

In some spinal frogs it was found that the posterior pair of lymph-hearts were not beating; presumably the spinal centre presiding over their action had been damaged by the operation. In such animals the paralysis of the lymph-hearts was permanent. I have never seen evidence of any beats in these spinal animals, and there is no indication that the action of the lymph-hearts is automatic.

I have to thank my student, Mr. Theodore Schrire, for assistance in the work.

B. F. J. Schonland,
Hon. General Secretary.

An Ordinary Meeting of the Society was held on Wednesday, May 15, 1929, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

Dr. A. Young was in the Chair.

Business:—

The Minutes of the Meeting held on April 17 were approved.

J. H. Dobson, D.S.O., D.Eng., M.Sc., was elected a Member of the Society.

H. G. Harris, proposed by Dr. A. L. du Toit, seconded by Miss Wilman, was nominated for Membership.

The Hon. General Secretary announced that the following are candidates for Fellowship in 1929:—Joseph Henry Dobson, D.S.O., D.Eng., M.Sc.; Edwin Leonard Gill, D.Sc.; Edith L. Stephens, B.A.

A resolution that the Society make application to the Research Grant Board for a grant in aid of the publication and printing of the Transactions, proposed by the Hon. General Secretary, and seconded by Dr. S. H. Haughton, was carried unopposed.

Communications:—

"Exhibition of Fossils from the Nama System of South-West Africa," by S. H. Haughton.

The fossils exhibited are, if the correlation of the Nama Beds of South-West Africa with the Transvaal System of the Union be accepted, the oldest fossil remains yet discovered in South Africa. They were found during the course of geological survey work by Haughton and Frommurze at Groendoorn, in the Warmbad District, at the top of the Kuibis Beds, below a thin limestone band which is taken as the local base of the Schwarzkalk. In this region the Schwarzkalk shows a local change of facies from a predominantly calcareous series, developed to the north and west, to a more arenaceous phase developed to the east, the former passing into the latter in a transition zone in which there are one or two thin limestone bands.

The organic remains found are of two kinds. One—occurring in a band of dark flaggy quartzite—consists of curving ridges of the type usually called "worm tracks," and shows no ornamentation. The others—which are found on one surface of a well-bedded red-weathering quartzite—consist of long, fairly straight, slightly tapering tubes from the basal end of which depends an irregular "stalk." The tube-like portion shows a regular ornamentation of longitudinal rows of pustules between which are longitudinal grooves; and there is evidence of the existence of transverse septa. The pustules are considered to be infillings of original "pores," the grooves as hollows originally filled by longitudinal internal septa. Of these the tube must have been supplied with about twelve.

It is suggested, therefore, that these remains are the internal casts of a stalked primitive coral-like form which was furnished with longitudinal and transverse septa, and whose walls were perforated by "pores," and attention is called to the possibility that the form is a member of the Archaeocyathinae, a group which had an almost world-wide distribution in the Lower Cambrian seas.

The usual occurrence of the Archaeocyathines in reefs of limestone suggests that the specimens under discussion may be merely isolated and detached fragments thrown up and embedded near a shore, and renders it important that careful search should be made in the more typical Schwarzkalk to the west and north for true reefs formed by these animals.

"The Volcanic Belt of the Lebombo—a Region of Tension," by A. L. du Toit.

B. F. J. Schonland,
Hon. General Secretary.

An Ordinary Meeting of the Society was held on Wednesday, August 21, 1929, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. W. A. JOLLY, was in the Chair.

Business:—

The Minutes of the Meeting held on July 17, 1929, were confirmed.

Communications:—

"On the Cleaning up of Civilisation," by C. K. O'MALLEY (communicated by the President).

"On Living Leucocytes," by J. H. FERGUSON.

The dark-ground microscope deserves a high place as an instrument of precision in determining critical cytological data, especially if the cells are kept alive in a reasonably normal environment. A drop of human blood examined by the "dark-ground illumination method" in a warm-chamber at 37° C. shows:

1. Colloidal particles and "haemokonia" in Brownian movement in the plasma. Also fibrin crystals and platelets associated with the phenomenon of "clotting."

2. Red cells—which evince their well-known cytological features. Their deformation, crenation, haemolysis, and (sometimes) their transformation into "demilune bodies" may be watched.

3. White cells are especially well studied in the living state, the five classical varieties being readily identified.

The leucocyte *nucleus* exhibits a fundamental degree of lobulation for each cell.

Nucleoli are prominent only in young cells.

The cytoplasm shows a clear structureless *hyaloplasm* containing oscillating refractile particles or *granules* of various kinds. *Mitochondria* and *vacuoles* are noted. All five types of leucocyte display active *amoeboid motility*. In the case of the polymorphs—neutrophil, eosinophil, and basophil—this is *continuous*; whereas in the case of the mononuclears—monocytes and (especially) lymphocytes—it is *intermittent* in character.

The *phagocytic powers* of the leucocytes for refractile objects, such as yeasts, may be demonstrated.

Certain "regressive changes" occur in the leucocytes and indicate surface-tension changes accompanying colloidal phenomena suggestive of the "sol" to "gel" transformation.

"A Proposed Method of Locating Underground Water and some Experiments thereon," by B. F. J. SCHONLAND.

A beam of short Hertzian waves incident at an angle of 45° upon the interface between dry earth or rock and underground water should undergo

reflection, and calculation for a wave-length of two metres indicates that the reflected intensity should amount to about 50 per cent. of the incident intensity.

Apparatus for the production and detection of such beams is described, measurements being made with a portable galvanometer, on a wave-length of 1·8 metres.

Preliminary experiments show that the method is feasible and should now be tested in the field. Interference between direct and reflected radiation has been observed, which suggests a possible modification of the method.

B. F. J. SCHONLAND,
Hon. General Secretary.

An Ordinary Meeting of the Society was held on Wednesday, June 19, 1929, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. W. A. JOLLY, was in the Chair.

Business:—

The Minutes of the Meeting held on May 15 were approved.

H. G. HARRIS was elected a Member of the Society.

The Hon. General Secretary announced the proposal of the Council in terms of the Statutes, Chapter L, Section XXII, to nominate Sir ARNOLD THEILER as an Honorary Fellow of the Society.

LEON VERWOERD, D.Sc. (Agric.), and JOHANNES THEODORUS POTGIETER, M.Sc., Ph.D., proposed by C. W. MALLY, seconded by B. DE ST. J. VAN DER RIET, were nominated to Membership of the Society.

Communications:—

"The Literature of Cayleyan Matrices," by Sir THOMAS MUIR.

"The Space Group and Symmetry of Potassium, Ammonium, and Rubidium Sulphates," by A. OGG.

The space group and symmetry of these sulphates were determined by the author to be Q_h16 (or V_h16) (Proc. Roy. Soc. S.A., July 1927). Details of the symmetry and atomic structures were published in the Phil. Mag. (vol. v, February 1928, p. 354). Since then Taylor and Boyer have confirmed the space group for ammonium and caesium sulphates (Proc. Manchester Phil. Soc., vol. lxxii, p. 125), and have given an atomic structure which is substantially the same.

F. P. Goeder (Proc. Nat. Acad. Sci., U.S.A., vol. xiii, No. 12) concludes from Laue photographs of potassium, rubidium, and caesium sulphates that the space group is V_h13. Reasons were given to show how the space

group V_h13 does not satisfy the experimental data, *e.g.* of the spacings along the principal axes being halved. It was also shown that the co-ordinates of the atoms in the fine structure given by Goeder (Proc. Nat. Acad. Sci., U.S.A., vol. xiv, No. 10) do not satisfy the conditions of symmetry of group V_h13.

The author concludes that the space group V_h13 is untenable and that the space group is V_h16, as originally determined, and afterwards confirmed by Taylor and Boyer.

"Germanium Dioxide in Aqueous Solution: Germanic Acid," by W. PUGH.

B. F. J. SCHONLAND,
Hon. General Secretary.

ANNUAL MEETING.

The Annual Meeting of the Society for the election of Fellows was held on September 25, 1929, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. W. A. JOLLY, was in the Chair.

Business:—

The following Candidates were elected Fellows of the Society:—JOSEPH HENRY DOBSON, D.S.O., D.Eng., M.Sc.; EDWIN LEONARD GILL, D.Sc.; EDITH L. STEPHENS, B.A.

ORDINARY MEETING.

An Ordinary Meeting was held after the Annual Meeting.

The President was in the Chair.

Business:—

The Minutes of the Ordinary Meeting held on August 21, 1929, were confirmed.

Mrs. G. E. G. RIMER, proposed by Professor L. HOGBEN, seconded by A. ZOOND, was nominated to Membership of the Society.

A resolution was passed expressing sympathy with Professor A. OGG in his illness and satisfaction at his recovery.

Communications:—

"The Cause of the Russell Effect observed in Oils," by J. C. VOGEL (communicated by the Hon. General Secretary).

"The Secular Variations of the Orbital Elements of the Inner Planets," by H. Spencer Jones.

It has been generally assumed that the theory of relativity, by accounting for the observed motion of the perihelion of Mercury, has removed the only outstanding discordance between the observed secular changes of the elements of the orbits of the planets (the eccentricity, inclination of the orbit to the ecliptic, the longitude of perihelion and the longitude of the node) and the values computed from the masses of the planets.

The system of masses of the planets upon which Newcomb based his tables of the Sun and planets was a compromise between the system of masses based upon the observed secular variations of the orbital elements and the system derived from satellites, periodic perturbations, etc. This adopted mass of the Earth corresponds to a value of the solar parallax of $8''\cdot79$, whereas the mean value from modern determinations by various methods gives a value of $8''\cdot802 \pm 0''\cdot002$.

Recent determinations by several different methods of the change in the obliquity of the ecliptic indicate an appreciable correction to Newcomb's value, which can be accounted for by an error in his adopted mass of Venus. Determinations of the mass of Venus from periodic perturbations of Mars and the Earth indicate a correction in the same sense. If this revised mass of Venus is adopted, the mass of the Earth deduced from the secular variations of the orbital elements corresponds to a still smaller value of the solar parallax.

The discordance can be traced to the motion of the node of Venus upon which the mass of the Earth obtained from the secular variations almost entirely depends. With the most probable system of masses, the discordance between the observed and the theoretical motions is six times the probable error. The motions of the node of Venus is the only remaining outstanding discordance between theory and observation in the planetary elements. A reinvestigation of this motion, utilising the forty years of modern observations which were not available to Newcomb, is greatly to be desired.

"The Wax of the Rhenoster Bush (*Elytropappus rhinocerotis*)," by B. de St. J. van der Riet and G. W. B. van der Lingen.

The air-dry tips of Rhenoster bush collected at Stellenbosch were found to yield on extraction with volatile organic solvents up to about 10 per cent. of wax-like material. The yield and nature of the "wax" varied according to the solvent used for extraction.

The solution obtained by treatment with warm *petroleum ether* gave a white deposit on cooling. This was collected and recrystallised from warm petroleum ether yielding, on expulsion of the solvent by fusion, a hard, light-coloured wax of m.p. (corr.) $79^\circ\cdot7$ to $80^\circ\cdot3$ C. (yield: 0·25 per cent.

In this case, and in what follows, percentage is reckoned on the dry herb).

The cold petroleum ether solution left on evaporation a dark, rather soft wax (yield: 3·8 per cent.).

Warm *absolute alcohol* also gave a deposit on cooling and a resultant light-coloured wax (yield: 1·1 per cent.). On the addition of water to the cold alcoholic solution, boiling off the alcohol, etc., there resulted a very dark, soft wax (yield: 7·3 per cent.). The aqueous solution further left, on complete evaporation of water, a brown mass with "molasses" odour and bitter taste (yield: 2·7 per cent.).

Acetone gave a yield of over 14 per cent. of a green, plastic, and rather sticky residue. The same statement holds for *ethylic ether*.

Warm *benzene* gave a very brittle wax, dark in colour when seen in mass, yellowish green in thin flakes (yield: 9·2 per cent.). The wax obtained by solution in warm *carbon tetrachloride* (yield: 10 per cent.) was very similar to the *benzene* extract, but appeared harder.

The wax obtained by carbon tetrachloride extraction had the following characteristics: acid value, 46·4; saponification value, 13·09; acetyl value, 175·8; iodine value, 17·4.

The authors hope to supply more information as to the nature of the wax in a later communication.

"The Problem of the Ventilation of Iron Roofs in the Tropics," by F. C. Cawston.

This is the description of an effort to secure good ventilation of iron roofs in the tropics, by a consideration of the climatic conditions at Durban, where a series of observations shows that the average room temperature is approximately 84 degrees through the summer, and may rise to 90 degrees on the hottest days.

The present demand for cooler rooms safeguards against atmospheric impurity; but the present system of ventilating iron roofs is very inadequate, and a cowl on the summit is insufficient unless there is a corresponding provision of air inlet.

It is advised that this inlet be provided by means of a ventilating shaft inserted on a slant at each corner of the roof to supplement adventitious draughts.

B. F. J. Schonland,
Hon. General Secretary.

An Ordinary Meeting of the Society was held on Wednesday, October 16, 1929, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

Dr. H. SPENCER JONES, Vice-President, was in the Chair.

Business:—

The Minutes of the Annual Meeting and of the Ordinary Meeting held on September 25, 1929, were confirmed.

Mrs. G. E. G. RIMER, proposed by Professor L. HOGBEN, seconded by A. ZOOND, was elected a Member of the Society.

H. HORROCKS, M.A., proposed by Dr. H. SPENCER JONES, seconded by the Hon. General Secretary, and E. L. HALLIDAY, M.Sc., proposed by Dr. A. OGG, seconded by the Hon. General Secretary, were nominated as Members of the Society.

The Vice-President gave notice of the Anniversary Election of the Council and Officers of the Society, and announced that the following were recommended by the Council for election for the year 1930:—

President, Dr. W. A. JOLLY; Treasurer, Dr. L. CRAWFORD; Secretary, Dr. B. SCHONLAND; Members of Council, Dr. A. OGG, Dr. J. SMEATH THOMAS, Professor H. PAINE, Dr. H. SPENCER JONES, Dr. L. GILL, Dr. P. A. VAN DER BYJL, Mr. J. HEWITT, Dr. L. HOGBEN, Dr. J. DALTON.

Communications:—

"Note on Monge's Relation between Primary Minors of a 3-by-5 Array," by Sir THOMAS MUIR.

"On a Blind Peripatus from the Table Mountain Caves," by R. H. LAWRENCE.

"Haemoglobin from Cases of Blackwater Fever," by J. S. VAN DER LINGEN.

"On an Instrument for Synchronous Recording of Two Simple Muscle Curves," by B. McMANUS and H. ZWARENSTEIN.

An instrument was described which has been designed for synchronous recording of the contractions of two gastrocnemei in Xenopus *in situ*.

B. F. J. SCHONLAND,
Hon. General Secretary.

ANNIVERSARY MEETING.

The Anniversary Meeting of the Society was held on Wednesday, March 19, 1930, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. W. A. JOLLY, was in the Chair.

The Report of the Hon. General Secretary was submitted and adopted.

The Report of the Hon. Treasurer was submitted and adopted.

The following were elected Members of Council for the year 1930:—

Dr. J. P. Dalton, Dr. E. L. Gill, Mr. J. Hewitt, Dr. L. T. Hogben, Dr. H. Spencer Jones, Dr. A. Ogg, Professor H. H. Paine, Dr. J. Smeath Thomas, Dr. P. A. van der Byjl.

Dr. W. A. Jolly was elected President; Dr. L. Crawford, Hon. Treasurer; and Dr. B. F. J. Schonland, Hon. General Secretary.

On the invitation of the President, Professor A. Young gave an account of the career of the late Dr. P. A. Wagner.

Percy Albert Wagner, D.Sc., Dr.Ing., M.E., F.G.S., F.R.S.S.Afr., was born at Richmond, in the Cape Province, in 1885, and educated at the S.A. College School and the S.A. College, Cape Town, and at the School of Mines, Johannesburg, where he graduated with distinction in 1906. He proceeded to carry out research work in Germany, at Freiberg and Heidelberg, from 1906 to 1909.

After acting on his return as Professor of Geology in Johannesburg, he became a consultant geologist, and carried out special investigations in South-West Africa. In 1919 he joined the staff of Geological Survey, becoming Senior Geologist. In 1922 he resigned from the Survey to take up an appointment as a consultant geologist.

He had at various times been President of the Geological Society of South Africa, and had served on the Council of the South African Association for the Advancement of Science. He formed important collections, illustrating the Economic Geology of South Africa and Pre-European Mining and Smelting, which are housed in the Universities of Cape Town and the Witwatersrand.

Dr. Wagner contributed over one hundred papers to the scientific and professional journals of South Africa, Europe, and America, and was an Associate Editor of "Economic Geology." He was the author of two works of wide reputation, The Diamond Fields of South Africa, and The Platinum Deposits and Mines of South Africa. He also wrote seven volumes of the Memoirs of the Geological Survey.

Ordinary Meeting.

An Ordinary Meeting was held after the Anniversary Meeting.

The President, Dr. W. A. Jolly, was in the Chair.

Business:—

The Minutes of the Meeting held on October 16, 1929, were confirmed.

H. Horrocks, M.A., and E. L. Halliday, M.Sc., were elected Members of the Society.

J. V. L. Rennie, M.A., proposed by Professor A. Young, seconded by the Hon. General Secretary; B. Farrington, M.A., proposed by the President, seconded by Professor Hogben; and V. H. Brink, M.Sc., M.A., M.R.C.P., proposed by Professor Drennan, seconded by the Hon. General Secretary, were nominated to Membership.

Communications:—

"The Blood-groups of the Bantu," by A. Pijper.

"Some Observations on the Embryonic Radula of Limnaeidae," by F. G. Cawston.

A consideration of the various individual teeth of Limnaeidae. The earliest appearance of the embryonic radula. Well-defined cones in the radula except at the anterior extremity. In the embryonic stage it is possible to recognise the marginal teeth with their denticles, the tricuspid laterals and the narrower central tooth of each row. Radulæ are best mounted in glycerine jelly. The front rows of the embryonic radula are bent back as is constant in the adult radula. The number of teeth increases rapidly after the egg hatches, until the mature individual mollusc possesses several thousand teeth.

"The Flora of the Whitehill District," by R. H. Compton.

"A Comparative Study of the Sacrum of the Griqua," by V. H. Brink (communicated by Professor M. Drennan).

"The Separate Identity of the Pressor and Pigmentary Effector Activity of Pituitary Extracts," by C. Gordon and L. Hogben.

By a new method which permits the assay of the melanophore stimulant with an order of precision comparable to the estimation of oxytoxic and pressor activity assays of the melanophore and pressor principles have been carried out simultaneously on the same samples treated in different ways. When exposed to the action of cold normal sodium hydroxide for two hours the pressor activity was found to be reduced more than 90 per cent. The pigmentary effector activity increased. The increase was doubtless due to the lack of interference resulting from concomitant vasomotor phenomena. The separate chemical identity of the two substances is thus indicated.

"Further Observations on the Relation of the Pituitary Gland to the Chromatic Function of *Xenopus laevis*," by D. Slome and L. Hogben.

The primary response recorded in a previous communication is not dependent on the C.N.S. nor on the pituitary gland: it is an inherent property of the pigmentary effector organ.

Complete section of the entire nerve-supply of a limb does not affect colour change in the operated region. Section of the C.N.S. at different levels does not result in segmental chromatic changes. Section of the

optic nerve in the orbit or at the chiasma has the same effect as removal of the eyes.

The comparison of reactions of totally hypophysectomised and normal toads (*a*) to photic stimuli, and (*b*) to the injection of posterior lobe extracts, yield data which reinforce the conclusion that the W-mechanism of a previous communication can be identified with the anterior lobe of the pituitary gland.

"Some Metabolic Changes associated with Pigmentary Effector Activity in *Xenopus laevis*," by Enid Hogben.

The dermal respiratory rate and the calcium and magnesium contents of the serum were investigated in Xenopus. The following classes of animals were employed: (1) Normal animals kept on white background; (2) normal kept on dark background; (3) eyeless; (4) hypophysectomised animals with both lobes removed, operated on over a year previously; (5) hypophysectomised with anterior lobe only removed, operated on over a year previously. Parallel series of males and females of (1), (2), and (3) were used. Eyeless animals were found to have a significantly higher respiratory rate than eyed animals. The effect of removing one or both lobes of the pituitary gland was found to be (*a*) to lower the dermal respiratory rate by about 24 per cent.; (*b*) to lower the calcium and magnesium content of the serum by about 30 per cent. These differences were shown to be statistically significant. Significant differences were shown to occur between males and females in all cases. Males had a higher respiratory rate than females. The calcium and magnesium content of the serum was lower in males than in females.

"Some Remarks on the Relation of the Pituitary Gland to Ovulation and Skin Secretion in *Xenopus laevis*," by L. Hogben.

The investigation of the rôle of the two lobes of the pituitary to pigmentary effector activity in Xenopus has brought to light some interesting phenomena in connection with the effects of removal, implantation, and injection of extracts of this gland.

1. *The Ovary.*—The autopsy of large females kept for two years after total operative removal of the gland revealed the fact that the ovary had undergone almost complete involution in all cases. This does not occur in animals kept in the laboratory without operative treatment. The involution of the ovary is externally indicated by the shrunken abdominal girth of the hypophysectomised animals. Implantation of glands from other individuals in June and in November induced ovulation. Injection of anterior lobe extracts prepared by Bellerby's method had the same effect. This suggests that the relation of the anterior lobe to the ovary is common to land vertebrates.

2. *Skin Secretion.*—After removal of the whole pituitary gland or the

anterior lobe alone, the copious secretion of slime, so characteristic a response of *Xenopus laevis*, ceases entirely: the skin assumes in consequence a leathery texture, and the animal can be readily picked up and held in the hand. The condition would not appear to be of vasomotor origin. It persists indefinitely after operation.

3. *Proliferation of Epidermal Cells.*—Injections of anterior lobe extract produce within a few hours complete shedding of the skin. The autocoid is heat stable and ether soluble.

"The Localisation of Respiratory Exchange in the Scorpion," by A. Zoond.

The book lungs of *Opisthophthalmus capensis* were occluded with a thin film of rubber solution. Determinations of oxygen consumption by means of the Haldane microrespiration manometer and of carbon dioxide production by the Pettenkoffer method showed that respiration was totally inhibited. The normal oxygen consumption was $61{\cdot}6 \pm 5{\cdot}7$ c.c. per kilo per hour, and the carbon dioxide produced was 83·6 c.c. per kilo per hour. The book lungs are therefore the only region of respiratory exchange in the scorpion, and there is no cutaneous respiration.

"The Localisation of Respiratory Exchange in the Polychaete *Bispira voluticornis*," by A. Zoond.

Determinations of dissolved oxygen by the Winkler method showed that when the branchial filaments of the polychaete were amputated the consumption of oxygen was reduced from a normal value of 82 mg. to 26 mg. per kilo per hour. The cutaneous respiration is thus 32 per cent. of the total, and the branchial filaments are the principal region of respiratory exchange.

"The Blood-Sugar Level in Normal and Eyeless *Xenopus laevis*," by L. P. Bosman and H. Zwarenstein.

Normal animals on white background . .	33 mg. per 100 c.c.
Normal animals on black background . .	35 ,, ,, ,,
Eyeless animals	59 ,, ,, ,,

(1) "Note on Sums of n-Line Minors pertaining to an n-by-$(n+2)$ Array. (2) Note on the Derivatives of the Eliminant of Two Binary Cubics," by Sir Thomas Muir.

B. F. J. Schonland,
Hon. General Secretary.

Report of the Hon. General Secretary for 1929.

Eight Ordinary Meetings, the Annual Meeting, and the Anniversary Meeting were held during the year, and the undermentioned papers were read:—

1. "Colour and Chemical Constitution, Part XXVI. (A) Pigments of Yellow Flowers. (B) Addenda to Previous Parts," by JAMES MOIR.

2. "Note on the Lagrangian of a Special Unit Determinant," by Sir THOMAS MUIR.

3. "Notes on the Karroo Reptilia from Madagascar," by S. H. HAUGHTON.

4. "A Study of the Genus *Colophon* (Coleoptera)," by K. H. BARNARD.

5. "The South African Species of *Rhus* L.," by S. SCHONLAND.

6. "Contributions to our Knowledge of the Freshwater Algae of Africa. 8. Bacillariales (Diatoms) from Griqualand West," by F. E. FRITSCH and FLORENCE RICH (communicated by Miss E. L. STEPHENS).

7. "Some Derivatives of Thiazole," by J. L. B. SMITH and R. H. SAPIRO.

8. "Report on the Natural History of Pans and other Fresh Waters of the Transvaal," by G. E. HUTCHINSON, G. E. PICKFORD, and J. F. M. SCHUURMAN (communicated by Dr. L. GILL).

9. "New and Noteworthy Mosses from South Africa," by H. N. DIXON and H. A. WAGER (communicated by V. A. WAGER).

10. "Thunderstorms and the Penetrating Rays," by B. F. J. SCHONLAND.

11. "On Recording Lymph-Heart Beats," by W. A. JOLLY.

12. "Exhibition of Fossils from the Nama System of South-West Africa," by S. H. HAUGHTON.

13. "The Volcanic Belt of the Lebombo: A Region of Tension," by A. L. DU TOIT.

14. "The Literature of Cayleyan Matrices," by Sir THOMAS MUIR.

15. "The Space Group and Symmetry of Potassium, Ammonium, and Rubidium Sulphates," by A. OGG.

16. "Germanium Dioxide in Aqueous Solution: Germanic Acid," by W. PUGH.

17. "Demonstration of some Antarctic Crustacea," by K. H. BARNARD.

18. "On Integrating Factors and Jacobi's Equation," by JOHN P. DALTON.

19. "A New Method of Observing Diurnal Variation of Magnetic Intensity and Declination using Field Instruments," by E. N. GRINDLEY.

20. "On the Cleaning up of Civilisation," by C. K. O'MALLEY (communicated by the President).

21. "On Living Leucocytes," by J. H. FERGUSON.

22. "A Proposed Method of Locating Underground Water and some Experiments Thereon," by B. F. J. SCHONLAND.

23. "The Cause of the Russell Effect observed in Oils," by J. C. VOGEL (communicated by the Hon. General Secretary).

24. "The Secular Variations of the Orbital Elements of the Inner Planets," by H. SPENCER JONES.

25. "The Wax of the Rhenoster Bush (*Elytropappus rhinocerotis*)," by B. DE ST. J. VAN DER RIET and G. W. B. VAN DER LINGEN.

26. "The Problem of Ventilation of Iron Roofs in the Tropics," by F. C. CAWSTON.

27. "Note on Monge's Relation between Primary Minors of a 3-by-5 Array," by Sir THOMAS MUIR.

28. "On a Blind Peripatus from the Table Mountain Caves," by R. H. LAWRENCE.

29. "Haemoglobin from Cases of Blackwater Fever," by J. S. VAN DER LINGEN.

30. "On an Instrument for Synchronous Recording of two Simple Muscle Curves," by B. MCMANUS and H. ZWARENSTEIN.

Vol. XVII, parts 2, 3, and 4, and Vol. XVIII, parts 1, 2, and 3, of the Society's Transactions have been issued during the year.

Sir ARNOLD THEILER, K.C.M.G., D.Sc., was elected an Honorary Fellow; and JOSEPH HENRY DOBSON, D.S.O., D.Eng., M.Sc.; EDWIN LEONARD GILL, D.Sc.; and EDITH L. STEPHENS, B.A., were elected Fellows of the Society in 1929.

Eight new Members were admitted during the year.

At the end of 1929 the number of Honorary Fellows was 1; Fellows 68; Members 149.

The deaths since the 1929 Anniversary Meeting of H. L. L. FELTHAM, J. MOIR, and P. A. WAGNER are recorded with regret.

During the year 6 Members resigned.

The exchanges with the Library have been maintained, and one new exchange has been arranged for.

Four hundred volumes of periodicals have been bound during the year, and it is hoped to bind a further four hundred during 1930.

An epidiascope has been purchased for the use of authors when bringing their communications before the Society.

1795 cards were sent by Dr. K. H. BARNARD to the International Catalogue of Scientific Literature during the year.

A new type of cover for reprints of papers has been arranged for.

A proposal that a certain number of addresses of a technical nature should be included in the Society's Meetings during the coming year has been approved.

The President offered a welcome to the British Association on behalf of the Society at its opening meeting on July 22.

The President represented the Society at the Centenary Celebrations of the University of Cape Town.

A deputation from the Council called upon Sir DOUGLAS MAWSON to convey the good wishes of the Society for the success of his expedition.

Messrs. Wheldon & Wesley have given up their overseas agency for the Society, and Messrs. Neill & Co., Edinburgh, have been appointed in their place.

ORDINARY MEETING.

An Ordinary Meeting of the Society was held on Wednesday, April 16, 1930, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. W. A. JOLLY, was in the Chair.

Business:—

The Minutes of the Anniversary and Ordinary Meetings held on Wednesday, March 19, 1930, were confirmed.

J. V. L. RENNIE, M.A.; V. H. BRINK, M.Sc., M.A., M.R.C.P.; and B. FARRINGTON, M.A., were elected Members of the Society.

LECTURE.—At the request of the Council a lecture, entitled "Diffuse Matter in Interstellar Space," was delivered by Dr. H. SPENCER JONES.

The President gave the thanks of the Society to the lecturer.

Communications:—

"On a Ground Stone Axe from a Cape Rock Shelter," by M. R. DRENNAN.

(*a*) "Some Ground Axes from Rhodesia and the Transvaal. (*b*) A New Variation of the Smithfield Culture from Natal," by A. J. H. GOODWIN.

"Some Phacopidae from the Bokkeveld Series," by J. V. L. RENNIE.

"Changes in the Composition of Oranges during Ripening. Part I. Changes in Weight," by P. VAN DER R. COPEMAN.

"A New Stone Implement Technique from Natal," by A. J. H. GOODWIN and W. E. JONES.

B. F. J. SCHONLAND,
Hon. General Secretary.

An Ordinary Meeting of the Society was held on Wednesday, May 21, 1930, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. W. A. JOLLY, was in the Chair.

Business:—

The Minutes of the Meeting held on April 16 were confirmed.

A. E. Bleksley, M.Sc., proposed by Dr. J. S. van der Lingen, seconded by the Hon. General Secretary, was nominated to Membership.

The Hon. General Secretary announced the names of the candidates for Fellowship in 1930.

Communications:—

"On the Occurrence of Upper Cretaceous Marine Fossils near Bogenfels, South-West Africa," by S. H. Haughton.

"The Breeding-Habits and Life-Histories of two Rare South African Amphibia.—I. *Hylambates natalensis*; II. *Natalobatrachus bonebergi*," by V. A. Wager.

"Changes in the Composition of Oranges during Ripening. Part II. Changes in Soluble Solids," by P. R. van der R. Copeman.

"The Life of Vesalius by Boerhaave and Albinus," by B. Farrington.

In 1725 Boerhaave and Albinus, both at that time professors at the University of Leyden, edited in two folio volumes the collected works of Andreas Vesalius. The most important of these works was the De Humani Corporis Fabrica, first published in 1542, and again in 1543, at Basle. This monumental and copiously illustrated treatise on Anatomy is the first great masterpiece in the history of modern science. In 1543 Copernicus published his work On the Revolutions of the Celestial Spheres, in which he overthrew the Ptolemaic system of astronomy. Similarly, the efforts of Vesalius, who was only twenty-eight years of age when he finished his masterpiece, were directed to the rescue of anatomy from a blind adherence to the teaching of Galen. His capital discovery was that Galen had in his description of human anatomy incorporated innumerable false statements derived from observations on monkeys and others of the lower animals. Every statement of Galen was tested by Vesalius in the course of years of assiduous dissection of human bodies, and his errors were found to be so many that Vesalius conceived it to be necessary to treat the whole subject afresh and to base every statement on personal observation. So thoroughly did he perform this task, and so rigorously did he confine himself to the recording of observed facts, that from the modern scientific point of view his work is superior even to that of his great Copernicus.

The communication consists of a translation of the Preface by Boerhaave and Albinus to their edition of the works of Vesalius. The Preface contains a brief history of Anatomy from the earliest times till its revival in Italy in the beginning of the fourteenth century. It gives a more extended account of the work of the Italian pioneers, and then establishes the epoch-making importance of the work of Vesalius. The career of Vesalius is treated in considerable detail and with many lively biographical touches. The Preface concludes with an account of the extraordinary activity in

anatomical research that followed on the teaching and writings of Vesalius, and draws special attention to the work of Fallopius and Eustachius.

Boerhaave and Albinus are both men of considerable importance in the history of science; this Preface of theirs is not now readily accessible in Latin, and has not before been translated into English, though presumably it has been a direct or indirect source of much subsequent writing on the history of Anatomy. The version has been elucidated by notes on a few passages.

"The Mechanism of Equilibration in *Xenopus laevis*," by A. Zoond and G. Rimer.

This paper deals with an analysis of the function of the eyes and the labyrinthine organs in connection with equilibrium and the response to rotation. Data are presented which show that whereas the extirpation of eyes and labyrinths abolishes completely the response to rotation on a turntable, eyed labyrinthless animals do respond to such rotation by definite muscular movement. This response is still maintained when the animal is rotated in total darkness. It is concluded that the eye of Xenopus performs an accessory labyrinthine function which is quite independent of retinal stimulation. The same phenomenon is recorded also for Rana.

"Dermal Photoreceptivity in *Xenopus laevis*," by A. Zoond.

The experimental data presented in this paper show that Xenopus is negatively phototropic. This response is not in any way affected by the removal of the eyes; the eyeless animals react to light in the same way as the eyed. Immersion in 1 per cent. cocaine solution for six minutes completely abolishes the sensitivity to light of the eyeless animals, although the spinal reflexes are not impaired by this treatment. These observations demonstrate the presence of photoreceptive elements in the skin of Xenopus.

B. F. J. Schonland,
Hon. General Secretary.

An Ordinary Meeting of the Society was held on Wednesday, June 18, 1930, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. W. A. Jolly, was in the Chair.

Business:—

The Minutes of the Meeting held on May 21 were confirmed.

A. E. Bleksley, M.Sc., proposed by J. S. van der Lingen, seconded by the Hon. General Secretary, was elected to Membership.

Communications:—

"On the Geographical Distribution of the Indo-African and Mediter-

ranean Gryllacoids," by H. H. KARNY (communicated by Dr. E. L. GILL and read by Dr. A. J. HESSE).

"Thunderstorms and the Penetrating Radiation," by B. F. J. SCHONLAND.

An examination of the effect of thunderclouds upon the intensity of the penetrating radiation, using a new type of ionisation electroscope, was made at Johannesburg in the summer of 1929–30. It has been found that overhead storms give rise to a reduction in intensity, amounting to as much as 40 per cent. No evidence could be obtained for the existence of beams of "run-away" electrons below these clouds. The reduction effect indicates that the majority, if not all, of the ionising particles have energies less than 5×10^9 electron-volts.

"Some Notes on the Physiology of *Teloschistes flavicans*," by J. B. CUTHBERT (communicated by Professor R. S. ADAMSON).

"Sex Differences in Serum Calcium in Different Classes of Vertebrates," by ENID HOGBEN.

The calcium and magnesium content of the serum was investigated in the following animals: the rabbit, domestic fowl, dogfish, clawed toad, and Cape crawfish. In the rabbit, dogfish, and crawfish the calcium content was higher in males than in females, but the difference was not statistically significant. In the fowl and toad the calcium content was significantly higher in females, the series of determinations being discontinuous. In the rabbit, fowl, and toad magnesium determinations gave parallel results to those of calcium. In the crawfish the magnesium content of the serum was significantly higher in the females. In the dogfish the magnesium content of the serum gave a wide range of values. It was suggested that this variability might be connected with the different stages of the reproductive cycle in the female.

B. F. J. SCHONLAND,
Hon. General Secretary.

An Ordinary Meeting of the Society was held on Wednesday, July 16, 1930, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

Dr. A. OGG, Ex-President, was in the Chair.

Business:—

The Minutes of the Meeting held on June 18 were confirmed.

A. LEEMANN, D.Sc., and Professor Dr. E. REUNING were nominated to Membership of the Society.

LECTURE.—Dr. STANLEY KEMP, Royal Research Ship "Discovery II,"

lectured upon the South Sandwich Islands. A vote of thanks, proposed by Dr. K. H. Barnard, seconded by Dr. L. Crawford, Hon. Treasurer, was communicated to Dr. Kemp by the Chairman.

Communications:—

"Note on Brioschi's Bordered Hessian," by Sir Thomas Muir.

"Exhibition of Mammoth and Elephant Teeth from the Vaal River Gravels," by S. H. Haughton.

The speaker exhibited a series of plaster casts of the type molars of several species of *Archidiskodon* and *Pilgrimia* described by Professor Dart. These molars were found at various levels in the gravels of the Vaal River, and the casts were made at the South African Museum, by kind permission of the authorities of the McGregor Museum, Kimberley, where the originals are housed.

Attention was drawn to the fact that nearly every elephant tooth discovered in these gravels has been made the type of a separate species; and a series of drawings of the molars of individuals of the existing African elephant from a single locality was shown to illustrate the large amount of variation possible within the limits of a single herd. It was pointed out that the amount of variation in the various races of African elephant remained to be studied, and that this variation should be considered in the discussion of the status of fossil forms.

The speaker also urged that caution should be used in the application of European terms such as *Pliocene* and *Pleistocene* in the description of South African land fossils.

"Changes in the Composition of Oranges during Ripening," by P. R. van der R. Copeman.

B. F. J. Schonland,
Hon. General Secretary.

An Ordinary Meeting of the Society was held on Wednesday, August 20, 1930, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. W. A. Jolly, was in the Chair.

Business:—

The Minutes of the Meeting held on July 16 were confirmed.

A. Leemann, D.Sc., proposed by Dr. E. P. Phillips, seconded by Dr. E. N. Doidge, and Professor Dr. E. Reuning, proposed by Dr. S. H. Haughton, seconded by the Hon. General Secretary, were elected to Membership.

Communications:—

"Steenbras Rainfall," by T. Stewart.

The first observations of rainfall were begun in February 1899. Four gauges were put into use during this month, and another three during the following April. Observations were taken of all these gauges up to October 6, 1899.

The rainfall observed during the eight months of 1899, although useful as giving the rainfall for that period, did not afford sufficient information for arriving at the vagaries of the falls in other years, so a correlation was made with the results which had been obtained at three gauges on Table Mountain for the same number of months and for a long term of years.

The conclusion the author arrived at, after comparing the rainfalls and the run-off, was that the yield of the catchment area for the wet months might be put at 6000 million gallons. This is the capacity of the reservoir which has recently been constructed.

In 1922 observations for a period of seven years were available. These showed that the average amount of rainfall in the main valley for that period was 40·7 inches. The observations taken since—that is, over a period of fourteen years—give 39·3 inches for the main valley.

The rainfall in the main valley cannot, however, be accepted as applying to the whole catchment. From the observations made by the author, the Kogel Berg and the other mountainous portions of the area receive a much heavier rainfall: while the average rainfall in the main valley may be put at about 40 inches per annum, that in the mountainous portions of the area may by analogy with the conditions at about the same elevation on Table Mountain be put at 70 inches per annum.

"The Cape Alder-Flies (*Megaloptera*)," by K. H. Barnard.

"A Note on Bridge's Genic Balance Theory of Sex Determination," by H. Zwarenstein.

The following modification is suggested: the female determining genes are located not only on chromosome X, but also on chromosome IV. The male determining genes are in chromosomes II and III. Assigning arbitrary values to the efficiency of these two interacting components, a series of sex indices is arrived at, which represents more truly the genotypic differences of the various sex types. This applies more especially to the differences between the male and female intersexes.

"Spinal Transection and the Chromatic Functions in *Xenopus laevis*," by L. T. Hogben.

The effects of section of peripheral nerves and of the C.N.S. at different levels have been investigated with the quantitative method elsewhere employed for investigating pigmentary effector activity in *Xenopus laevis*. Section of the optic nerve has the same effect as removal of the eyes. Section of the entire peripheral nerve supply of the leg has no effect on colour response. Both the black and white background response can be

elicited in toads after section of the cord in front of the first pair of spinal nerves or at any lower level.

"The Total Oxygen Consumption of Hypophysectomised Toads," by ENID HOGBEN.

The total respiratory exchange of *Xenopus laevis* has been studied in animals deprived of one or both lobes of the pituitary gland, in eyeless animals and in normal animals showing the black and white background responses. The ratio of dermal (Winkler method) to pulmonary (Haldane method) respiration has been determined, and the variation of total respiratory rate with temperature, body-weight, and sex have been determined. The most significant result is that removal of the pituitary gland is accompanied by a profound diminution in the oxygen consumption.

"Discoveries in a Bushman Cave at Tafelberg Hall," by J. HEWITT.

B. F. J. SCHONLAND,
Hon. General Secretary.

ANNUAL MEETING.

The Annual Meeting for the Election of Fellows was held on Wednesday, September 24, 1930, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. W. A. JOLLY, was in the Chair.

The following were elected as Fellows of the Society:—R. A. DART, M.Sc., M.B.; A. J. H. GOODWIN, M.A., F.R.A.I.; J. S. HENKEL; M. R. LEVYNS, B.A.; H. E. WOOD, M.Sc., F.R.A.S.

ORDINARY MEETING.

The Annual Meeting was followed by an Ordinary Meeting.

Business:—

The Minutes of the Meeting held on August 20 were confirmed.

C. VAN RIET LOWE, proposed by Sir CARRUTHERS BEATTIE, seconded by Professor L. CRAWFORD, was nominated to Membership.

Communications:—

"The Theory of Electrolytic Valve Action," by E. NEWBERY.

The phenomena associated with electrolytic valve action were briefly described, and some records of the potential changes obtained with the aid of the cathode ray oscillograph were shown. Previous theories of valve action are inadequate for explaining the rectifying action of these valve electrodes for frequencies of the order of fifty per second. It was

suggested that an insulating anodic film is built up, which is impermeable to the large anions usually present but permeable to hydrogen ions. As the films are very thin and the hydrogen ions very rapid, there is no difficulty in accounting for the observed rapid changes of potential. All the known phenomena of electrolytic valve action may be accounted for on the basis of this theory.

"Thunderstorms and the Penetrating Radiation (II)," by B. F. J. SCHONLAND.

The reduction in the intensity of the penetrating radiation under thunderstorms, referred to in a previous communication, was discussed in relation to the electrical state of the cloud as determined from field change observations. Thunderclouds which seem to have an excess positive charge elevated above a negative charge produce much larger reductions than the more usual type, in which the excess, if any, is with the lower negative pole.

This can be readily interpreted if the primary radiation consisted either of positively charged particles or of ultraganima quanta, but it does not support the view that radiation is made up of fast Beta rays.

The possibility of utilising thunderclouds to give decisive test as to the nature of the radiation was discussed.

"Holism," by A. C. LEEMANN.

B. F. J. SCHONLAND,
Hon. General Secretary.

An Ordinary Meeting of the Society was held on Wednesday, October 15, 1930, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. W. A. JOLLY, was in the Chair.

Business:—

On the motion of the President the Meeting passed a resolution of sympathy with the relatives of the late Sir JOHN BUCHANAN.

The Minutes of the Ordinary Meeting held on September 24, 1930, were confirmed.

C. VAN RIET LOWE was elected to Membership of the Society.

Mrs. M. LEVYNS, B.A., was admitted as a Fellow of the Society.

The President gave notice of the Anniversary Meeting, and announced that the following were recommended by the Council for election for the year 1931:—

President, Dr. W. A. JOLLY; Hon. Treasurer, Dr. L. CRAWFORD; Hon. General Secretary, Dr. B. F. J. SCHONLAND; Members of Council, Dr. K. BARNARD, Dr. P. VAN DER BYJL, Dr. W. CAMPBELL, Dr. L. GILL,

Mr. F. E. Kanthack, Dr. J. T. Morrison, Dr. A. Ogg, Dr. H. Spencer Jones, Dr. P. J. du Toit.

Communications:—

"A Contribution to the Geology of the Western Edge of Bushmanland," by E. Reuning.

"On a Collection of Fossil Frogs from the Clays at Banke, Namaqualand," by S. H. Haughton.

"On the Fossil Leaves from the Clays at Banke, Namaqualand," by J. V. L. Rennie.

"On Silicified Wood from the Surface Quartzites of Banke, Namaqualand," by R. S. Adamson.

"Note on some Recent Experiments on the Germinating Capacity of Rhenoster Seed," by M. R. Levyns.

"The Life-History of *Lunularia*, with special reference to the Archegoniophore and Sporophyte," by W. T. Saxton (communicated by R. S. Adamson).

"A Cytological Investigation of *Garrya elliptica*," by M. H. Giffen (communicated by M. R. Levyns).

"The Pomona-Quartzite and Oyster-Horizon on the West Coast of South Africa north of the Oliphants River Mouth," by E. Reuning.

A description is given of the results obtained from examination of the Tertiary beds on the farm "The Point," on the Van Rhyns Dorp coast. It is shown that ancient phyllites are planed off and covered by a series of deposits which consist of a fossiliferous grit with sharks' teeth at the base, followed by a strongly silicified sand and grit passing up into calcified and partly silicified clays. Lying unconformably upon these sands and clays—which are considered to be equivalents of the Pomona quartzite—are marine deposits divided into the Main Oyster Horizon below and the *Donax rogersi* beds above. Above these is a terrestrial cover of sand, which has been formed in a discontinuous cycle, as is evidenced by intermediate layers of sand with rootlets and calcified layers.

"A Report on the Cape Flats Femur," by T. Levitt (communicated by M. R. Drennan).

This paper records a detailed study of the thigh-bone found in a sand quarry on the Cape Flats, under the same circumstances as a skull, which has proved to be decidedly primitive. In order to ascertain the morphological status of the femur, numerous measurements and indices, devised by various authorities, have been applied to it, and the results have been compared with considerable data similarly obtained from Bushman, Bantu, and other primate thigh-bones.

The consistency with which this femur shows primitive human and even simian characters demonstrates that it must have belonged to an

individual appreciably different from any of the existing human types in Africa, and definitely low in the human scale. This finding corresponds with that arrived at independently for the skull, so that these two specimens probably belonged to the same individual, who was neither Bushman nor Bantu, but a member of a much more primitive race.

(*a*) "The Thyroid Gland in *Xenopus laevis*. (*b*) The Pituitary Gland in *Xenopus laevis*," by Mrs. G. RIMER.

B. F. J. SCHONLAND,
Hon. General Secretary.

ANNIVERSARY MEETING.

The Anniversary Meeting of the Society was held on Wednesday, March 18, 1931, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. W. A. JOLLY, was in the Chair.

The Report of the Hon. General Secretary was submitted and adopted.

The Report of the Hon. Treasurer was submitted and adopted.

The Meeting passed a resolution, moved by Professor MORRISON and seconded by Professor NEWBERY, asking the Council to protest against the drastic reduction in the Government Grant to the Society for 1931.

The Meeting passed a vote of thanks to the Auditors, Professors RYRIE and GUNN.

The following were elected as Officers and Members of Council for the year 1931:—President, Dr. W. A. JOLLY; Hon. Treasurer, Dr. L. CRAWFORD; Hon. General Secretary, Dr. B. F. J. SCHONLAND; Members, Dr. K. BARNARD, Dr. P. VAN DER BYJL, Dr. W. CAMPBELL, Dr. L. GILL, Mr. F. E. KANTHACK, Dr. J. T. MORRISON, Dr. A. OGG, Dr. H. SPENCER JONES, Dr. P. J. DU TOIT.

ORDINARY MEETING.

An Ordinary Meeting was held after the Anniversary Meeting.

Business:—

The Minutes of the Meeting held on October 15, 1930, were confirmed.

E. D. MOUNTAIN, M.A., proposed by Mr. J. HEWITT, seconded by the Hon. Secretary; T. A. STEPHENSON, D.Sc., proposed by the President, seconded by Dr. A. ZOOND; I. SHAPERA, M.A., Ph.D., proposed by Mr. GOODWIN, seconded by Professor BARNARD; I. SCHRIRE, B.A., proposed by Dr. ZWARENSTEIN, seconded by the President, were nominated to Membership.

Communications:—

"The Ancient Iron-smelting Cavern at Mumbwa," by R. A. DART and NINO DEL GRANDE.

"On a New Species of Aristea," by R. S. ADAMSON.

"The Effect of Castration upon Protein Metabolism," by H. ZWARENSTEIN and I. SCHRIRE.

Total castration of male rabbits leads to an increase in weight and to a 25–40 per cent. increase in creatinine excretion three months after operation. Grafting of testes caused a return to normal within a fortnight.

The creatinine excretion of a female rabbit showed a 20 per cent. decrease three months after removal of the ovaries.

"Perceptual Tests of General Intelligence for International Use," by M. FORTES.

(*a*) "Note on Equalities Connecting Two Sums of Squares. (*b*) Note on a Special Alternant of Three Variables," by Sir THOMAS MUIR.

"A Sketch of the Floral Regions of Tanganyika Territory," by J. F. V. Phillips.

B. F. J. SCHONLAND,
Hon. General Secretary.

REPORT OF THE HON. GENERAL SECRETARY FOR 1930.

Eight Ordinary Meetings, the Annual Meeting, and the Anniversary Meeting were held during the year, and the undermentioned papers were read:—

1. "The Blood-Groups of the Bantu," by A. PIJPER.
2. "Some Observations on the Embryonic Radula of Limnaeidae," by F. G. CAWSTON.
3. "The Flora of the Whitehill District," by R. H. COMPTON.
4. "A Comparative Study of the Sacrum of the Griqua," by V. H. BRINK.
5. "The Separate Identity of the Pressor and Pigmentary Effector Activity of Pituitary Extracts," by G. GORDON and L. HOGBEN.
6. "Further Observations on the Relation of the Pituitary Gland to the Chromatic Function of *Xenopus laevis*," by D. SLOME and L. HOGBEN.
7. "Some Metabolic Changes associated with Pigmentary Effector Activity in *Xenopus laevis*," by ENID HOGBEN.
8. "Some Remarks on the Relation of the Pituitary Gland to Ovulation and Skin Secretion in *Xenopus laevis*," by L. HOGBEN.
9. "The Localisation of Respiratory Exchange in the Scorpion," by A. ZOOND.
10. "The Localisation of Respiratory Exchange in the Polychaete *Bispira voluticornis*," by A. ZOOND.

11. "The Blood-Sugar Level in Normal and Eyeless *Xenopus laevis*," by L. P. Bosman and H. Zwarenstein.

12. (1) "Note on Sums of n-Line Minors pertaining to an n-by-$(n+2)$ Array. (2) Note on the Derivatives of the Eliminant of Two Binary Cubics," by Sir Thomas Muir.

13. "On a Ground Stone Axe from a Cape Rock Shelter," by M. R. Drennan.

14. (*a*) "Some Ground Axes from Rhodesia and the Transvaal. (*b*) A New Variation of the Smithfield Culture from Natal," by A. J. H. Goodwin.

15. "Some Phacopidae from the Bokkeveld Series," by J. V. L. Rennie.

16. "Changes in the Composition of Oranges during Ripening. Part I. Changes in Weight," by P. R. van der R. Copeman.

17. "A New Stone Implement Technique from Natal," by A. J. H. Goodwin and W. E. Jones.

18. "On the Occurrence of Upper Cretaceous Marine Fossils near Bogenfels, South-West Africa," by S. H. Haughton.

19. "The Breeding Habits and Life-Histories of two Rare South African Amphibia.—I. *Hylambates natalensis*. II. *Natalobatrachus bonebergi*," by V. A. Wager.

20. "Changes in the Composition of Oranges during Ripening. Part II. Changes in Soluble Solids," by P. R. van der R. Copeman.

21. "The Life of Vesalius by Boerhaave and Albinus," by B. Farrington.

22. "The Mechanism of Equilibration in *Xenopus laevis*," by A. Zoond and G. Rimer.

23. "Dermal Photoreceptivity in *Xenopus laevis*," by A. Zoond.

24. "On the Geographical Distribution of the Indo-African and Mediterranean Gryllacoids," by H. H. Karny (communicated by Dr. E. L. Gill).

25. "Thunderstorms and the Penetrating Radiation," by B. F. J. Schonland.

26. "Some Notes on the Physiology of *Teloschistes flavicans*," by J. B. Cuthbert.

27. "Sex Differences in Serum Calcium in Different Classes of Vertebrates," by Enid Hogben.

28. "Note on Brioschi's Bordered Hessian," by Sir Thomas Muir.

29. "Exhibition of Mammoth and Elephant Teeth from the Vaal River," by S. H. Haughton.

30. "Changes in the Composition of Oranges during Ripening," by P. R. van der R. Copeman.

31. "Steenbras Rainfall," by T. Stewart.

32. "The Cape Alder-Flies (Megaloptera)," by K. H. Barnard.

33. "A Note on Bridge's Genic Balance Theory of Sex Determination," by H. Zwarenstein.

34. "Spinal Transection and the Chromatic Functions in *Xenopus laevis*," by L. T. Hogben.

35. "The Total Oxygen Consumption of Hypophysectomised Toads," by Enid Hogben.

36. "Discoveries in a Bushman Cave at Tafelberg Hall," by J. Hewitt.

37. "The Theory of Electrolytic Valve Action," by E. Newbery.

38. "Thunderstorms and the Penetrating Radiation, II," by B. F. J. Schonland.

39. "Giant Crescents," by C. van Riet Lowe (communicated by Sir Carruthers Beattie).

40. "Holism," by A. C. Leemann.

41. "A Contribution to the Geology of the Western Edge of Bushmanland," by E. Reuning.

42. "On a Collection of Fossil Frogs from the Clays at Banke, Namaqualand," by S. H. Haughton.

43. "On the Fossil Leaves from the Clays at Banke, Namaqualand," by J. V. L. Rennie.

44. "On Silicified Wood from the Surface Quartzites of Banke, Namaqualand," by R. S. Adamson.

45. "Note on some Recent Experiments on the Germinating Capacity of Rhenoster Seed," by M. R. Levyns.

46. "The Life-History of *Lunularia*, with special reference to the Archegoniophore and Sporophyte," by W. T. Saxton (communicated by R. S. Adamson).

47. "A Cytological Investigation of *Garrya elliptica*," by M. H. Giffen (communicated by M. R. Levyns).

48. "The Pomona-Quartzite and Oyster-Horizon on the West Coast of South Africa north of the Oliphants River Mouth," by E. Reuning.

49. "A Report on the Cape Flats Femur," by T. Levitt (communicated by M. R. Drennan).

50. (*a*) "The Thyroid Gland in *Xenopus laevis*. (*b*) The Pituitary Gland in *Xenopus laevis*," by Mrs. G. Rimer.

Volume XVIII, part 4, and Volume XIX, part 1, of the Society's Transactions have been issued during the year.

Raymond A. Dart, M.Sc., M.B., Ch.B.; Astley John Hilary Goodwin, M.A., F.R.A.I.; John Spurgeon Henkel; Margaret R. Levyns, B.A.; and Harry Edwin Wood, M.Sc., F.R.A.S., were elected Fellows of the Society in 1930.

Nine new Members were elected during the year.

At the end of 1930 the number of Honorary Fellows was 1, Fellows 71, Members 142.

The deaths since the 1930 Anniversary Meeting of Sir John Buchanan, Hon. J. W. Jagger, N. Janisch, A. Walsh are recorded with regret.

During the year six Members resigned, and the names of two Members were struck off the list.

The following gifts were received by the Library during 1930:—

From the Director, McGregor Museum, Kimberley, The Bantu Tribes of South Africa, by A. M. Duggan-Cronin; from the relatives of the late Sir John Buchanan, a set of Transactions and Proceedings; from the Oxford University Press, Sea-Angling Fishes of the Cape, by C. L. Biden.

The exchanges with the Library have been maintained, and new exchanges arranged with the following institutions:—Musée du Congo Belge; Royal Irish Academy; Marine Biological Station, Woods Hole, Massachusetts.

Four hundred volumes of periodicals have been sent for binding during the year, and it is hoped to bind a further four hundred during 1931.

1643 cards were sent to the International Catalogue of Scientific Literature by Dr. K. H. Barnard.

At the invitation of the Council, Dr. H. Spencer Jones, F.R.S., Astronomer Royal at the Cape, and Dr. Stanley Kemp, of R.R.S. "Discovery II," lectured before the Society in Cape Town.

Dr. E. Leonard Gill has consented to act as Honorary Librarian to the Society.

Professor R. S. Adamson was appointed to represent the Society at the International Botanical Congress at Cambridge in 1930.

An agreement has been entered into with the University of Cape Town for the removal of the Society's Library from the Hiddingh Hall, Cape Town, to the University Library building at Groote Schuur, Rondebosch, and for the University Library staff to undertake the charge and working of the Society's Library, which will be maintained as a separate unit. Under the agreement Members will have the use of the University Library as well. Information as to the arrangements made for the supply of volumes to members by post or otherwise will be circulated as soon as the removal has taken place.

The Secretary for Mines and Industries received a deputation from the Society in August in connection with the removal of the funds at the disposal of the Research Grant Board. As a result of the representations made, the Minister restored research grants for work in progress.

B. F. J. Schonland,
Hon. General Secretary.

REVENUE AND EXPENDITURE ACCOUNT FOR THE YEAR ENDING DECEMBER 31, 1930.

Revenue.

	£	s.	d.	£	s.	d.
To Subscriptions collected for 1930:—						
Subscriptions collected for 1928	3	0	0			
,, ,, 1929	34	0	0			
,, ,, 1930	275	0	6			
,, ,, 1931	2	17	0			
,, collected in advance for 1930	11	4	6			
Outstanding Subscriptions at December 31, 1930	55	15	0			
	381	17	0			
Less: Outstanding Subscriptions as in Statement December 31, 1929, £44; Subscriptions collected in 1930 for 1931, £2 17s.	46	17	0			
				335	0	0
,, Entrance Fees				11	0	0
,, Government Grant				300	0	0
,, Interest received:—						
On Fixed Deposit, £350, at Standard Bank for one year at 4¾ per cent.	16	12	6			
On £408 New Union of South Africa 5 per cent. Stock	20	8	0			
On Money in Savings Bank Department of Standard Bank	5	19	10			
				43	0	4
,, Sale of Publications in 1930	59	11	7			
Plus: Amount due for Sales in 1930 ..	2	14	1			
	62	5	8			
Less: 1928 and 1929 Accounts paid in 1930	3	1	5			
				59	4	3
				£748	4	7

Expenditure.

	£	s.	d.	£	s.	d.	£	s.	d.
By Publications:—									
Cash paid to Messrs. Neill & Co., for Printing, etc.				432	4	0			
Cost of Bank Drafts				2	8	9			
				434	12	9			
Less: Paid for Vol. XVIII., Pt. 3, issued 1929				123	14	1			
				310	18	8			
Less: Receipts for extra Reprints of Papers ..	£6	5	3						
Plus: Amount due for Sales in 1930	1	10	0						
				7	15	3			
							303	3	5
,, Compilation of International Catalogue of Scientific Papers							16	16	0
,, Clerical Assistance and Work in Library ..				84	0	0			
Less: 1929 Account paid in 1930				12	0	0			
							72	0	0
,, Local Printing and Stationery				44	8	6			
Less: Sale of Reprints of Minutes of Meeting				1	13	9			
							42	14	9
,, Postages and Petties							17	1	2
,, Binding							93	4	6
,, Bank Charges for Commissions, Ledger Fees, Fixed Deposit Stamps, etc.				4	0	11			
Less: Commissions paid by Members ..				1	19	5			
							2	1	6
,, Hire of Rooms and Caretaker							6	6	0
,, Insurance of Library in Cape Town and of back Numbers with Neill & Co. ..							1	3	9
,, Profit in year 1930							193	13	6
							£748	4	7

In the expenditure during any calendar year the amount spent in printing the Transactions is much the largest item. The printing of the Transactions, however, do not appear at regular intervals. The profit in 1930 is due to the fact that a Part was issued in December 1929, at a cost of £124, and another in January 1931, at a cost of £160, neither of these items coming into the 1930 accounts. The cost of the former was mainly responsible for the loss by the Society in 1929 of £146.

ASSETS AND LIABILITIES AS AT DECEMBER 31, 1930.

Assets.*	£ s. d.	Liabilities.		£ s. d.
Money at Standard Bank on Fixed Deposit for one year at 5 per cent.	350 0 0	Subscriptions received in 1930 for 1931		2 17 0
Money in Savings Bank Department of Standard Bank	190 13 3	Excess of Assets over Liabilities:—		
Balance at Standard Bank, as per Pass Book	73 1 3	Amount at December 31, 1929	£877 3 1	
Union of South Africa £408 5 per cent. Stock, 1929 1939, reckoned at purchase price	400 0 0	Add: Profit in 1930	193 13 6	1070 16 7
Arrears of Subscriptions, as in Statement for 1929, £44, less £33 paid in 1930 and £2 struck off as irrecoverable	9 0 0			
Arrears of Subscriptions for 1930, less £2 struck off as irrecoverable	46 15 0			
Amount due for Sale of Publications in 1930	2 14 1			
Amount due for Sale of Extra Reprints in 1930	1 10 0			
	£1073 13 7			£1073 13 7

* Exclusive of value of Library and Publications of the Society held in Stock.

Entrance Fees and Life Subscriptions Fund.

	£ s. d.		£ s. d.
Amount of Fund at January 1, 1930	415 0 0	Amount of Fund at December 31, 1930	426 0 0
Entrance Fees received in 1930	11 0 0		
	£426 0 0		£426 0 0

We hereby certify that we have examined the above accounts of Revenue and Expenditure, and of Assets and Liabilities, with the books, vouchers, and other documents and securities relating thereto, and that, in our opinion, these accounts set forth a correct statement of the affairs of the Society.

B. J. RYRIE.
J. W. C. GUNN.

February 12, 1931.

ORDINARY MEETING.

An Ordinary Meeting of the Society was held on Wednesday, April 15, 1931, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. W. A. JOLLY, was in the Chair.

Business:—

The Minutes of the Anniversary Meeting and of the Ordinary Meeting held on Wednesday, March 18, were confirmed.

E. D. MOUNTAIN, M.A., proposed by Mr. J. HEWITT, seconded by the Hon. Secretary; T. A. STEPHENSON, D.Sc., proposed by the President, seconded by Dr. A. ZOOND; I. SCHAPERA, M.A., Ph.D., proposed by Mr. GOODWIN, seconded by Professor BARNARD; I. SCHRIRE, B.A., proposed by Dr. ZWARENSTEIN, seconded by the President, were elected to Membership.

Communications:—

"Vesalius on Vivisection," by B. FARRINGTON.

This paper is a translation of the last chapter of the De Humani Corporis Fabrica of Vesalius, which bears the title "Some Observations on the Dissection of Living Things." Though Vesalius did not advance the study of physiology to anything like the same degree as he did the science of anatomy, his book is, none the less, in the words of Sir M. Foster, "the beginning not only of modern anatomy but of modern physiology." The physiological experiments described by Vesalius have a direct connection with the series of observations on living animals that enabled Harvey to demonstrate the circulation of the blood. The experiments were established by Vesalius as a regular part of his anatomical demonstrations in the University of Padua. His successor in this chair was his pupil Falloppius. He in his turn was succeeded by his pupil Fabricius. And it was under him that Harvey studied at Padua from 1598–1602, when he received the degree of Doctor of Medicine and returned to England.

"On the Herpetological Fauna of the Lobatsi-Linokana Area," by J. H. POWER.

An unexpected result of the author's collecting at Linokana was the discovery, in many cases, of different species of certain genera, from those found at Lobatsi. The two localities are connected by a narrow valley between two ranges of hills, seemingly an admirable condition for ensuring that the reptile and amphibian faunas should be the same.

The list of species collected materially extends the range of many species.

The relationships of *Gerrhosaurus flavigularis* and *G. nigrolineatus*, and *Bufo tuberculosus and B. regularis gutturalis*, are discussed.

"Western Mediterranean Parallels with the Stone Age in South Africa," by A. J. H. GOODWIN.

"Tissue Respiration in Relation to the Physiology of Infection," by W. CAMPBELL and W. GERSHOLOWITZ.

"The Reaction of Xenopus to Digitalis," by J. W. C. GUNN and D. EPSTEIN.

In a previous paper (Trans. Roy. Soc. S. Afr., x, p. 55, 1921) it was shown that *Xenopus laevis*, the South African clawed toad, reacted to digitalis bodies quantitatively like Rana and not like Bufo.

It has been stated more recently that in Rana there are unexplainable variations in the response to digitalis as shown by the differences in the minimal lethal doses in individual animals on any one day, in groups of animals from day to day, and in other ways. Such variations are not seen with Xenopus even when kept in captivity for several months. It is therefore superior to Rana for the biological assay of digitalis by any of the frog methods.

"The Adrenal Secretion of *Xenopus laevis*," by D. EPSTEIN, J. W. C. GUNN, E. EPSTEIN, and G. RIMER.

Morphologists claim that no adrenal bodies are present in *Xenopus*, and various hypotheses have been brought forward to account for the absence of these glands.

We have shown experimentally the presence of adrenaline in extracts of the kidneys of *Xenopus*. The kidney tissue itself contains no adrenaline, but the active substance is derived apparently from thin yellow streaks present on the ventral surfaces of the kidneys. These streaks probably represent the adrenal glands of *Xenopus*. This has been confirmed histologically by the demonstration of chromaffin tissue.

"South African Bryophyta: Further Notes," by T. R. SIM.

B. F. J. SCHONLAND,
Hon. General Secretary.

An Ordinary Meeting of the Society was held on Wednesday, May 20, 1931, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. W. A. JOLLY, was in the Chair.

Business:

The Meeting passed a resolution of sympathy with the family of the late Dr. R. MARLOTH. Professor OGG, in moving the resolution, referred to Dr. MARLOTH's great services to the Society.

RUDOLF MARLOTH was born at Lubben, Germany, on December 28, 1855, and died at Caledon on May 15, 1931.

He was a student at the University of Berlin, where he studied Botany under Schwendener.

MARLOTH came to South Africa in 1883 as Professor of Chemistry at the Victoria College, Stellenbosch, later being transferred to Elsenberg. Since 1904 he practised as an Analytical Chemist in Cape Town. It is, however, as a botanist and for his botanical work that he is best known, and for which he has received recognition far beyond the bounds of South Africa.

MARLOTH was a member and at one time President of the South African Philosophical Society, and was elected a Fellow of the Royal Society on its incorporation in 1908. He contributed numerous papers to the Transactions of the Philosophical Society and Royal Society, and to other periodicals.

His major works are Das Kapland, published in 1898, a pioneer work on the lines of modern ecology, and in many ways the greatest work MARLOTH wrote, and The Flora of South Africa, the last volumes of which are now in the press. This work contains an immense mass of original observation on the flora.

Among his other important contributions are papers on "Window Plants," "Mimicry in Plants," "Deposition of Moisture from S.E. Clouds," and numerous contributions on the biology and systematics of South African plants.

He also wrote an elementary textbook of botany, which was used for many years in schools.

MARLOTH was President of the South African Association for the Advancement of Science in 1914, and that year was awarded the South African Medal. He was awarded the Captain Scott Medal by the Biological Society in 1923. Honorary degrees were conferred on him by the Universities of Stellenbosch, 1922; Cape Town, 1929; and Heidelberg, 1929.

The Minutes of the Meeting held on April 15 were confirmed.

M. A. POCOCK, B.Sc., proposed by Professor ADAMSON, seconded by Miss E. L. STEPHENS; G. M. DREOSTI, D.Sc., proposed by Dr. P. R. COPEMAN, seconded by the Hon. General Secretary; E. A. GRIFFITHS, M.Sc., proposed by the Hon. General Secretary, seconded by Professor OGG, were nominated to Membership of the Society.

LECTURE.—Dr. S. H. HAUGHTON delivered a lecture on "The Geological History of the South Atlantic Ocean." A vote of thanks from the Chair was seconded by Professor YOUNG.

Communications:—

"Correlations between the Field Changes due to Lightning and the Appearance of the Flashes," by E. L. HALLIDAY.

A preliminary note upon certain results obtained in investigations of the polarity of thunderstorms in the Transvaal. Photographic records of the field changes due to lightning discharges have been combined with

visual and photographic observations of the flashes. Of 273 flashes between the base of the cloud and the ground, 257 gave positive field changes and 16 gave negative field changes. Of 173 positive field changes at distances greater than 7 km., 159 were due to flashes to ground. Of 164 discharges within the cloud at distances greater than 7 km., 150 gave negative changes of field.

These results confirm those obtained by SCHONLAND for South African thunderstorms.

"Point Discharge Measurements below Thunderstorms," by B. F. J. SCHONLAND and C. A. COPPENS.

A method of studying the fields and field changes of thunderstorms by observations on the current due to point discharge. The arrangement used by the authors in Johannesburg and Graaff-Reinet utilises a suitably insulated point and a portable galvanometer. Its simplicity lends itself to the collection of statistical data on the sign and order of magnitude of the fields and field changes. The arrangement leaves the observer fairly free to note the meteorological features and the distance of the storm. The discussion of the data obtained will be given elsewhere.

"The Alkaloids of the Bark of *Strychnos henningsii*" (second communication), by M. RINDL.

Two alkaloids have been isolated from the bark of *Strychnos henningsii*, a crystalline and an amorphous one. The crystalline alkaloid has been previously described by the author. The present paper deals with the methods adopted to isolate the amorphous alkaloid and the endeavours to obtain the base itself, or derivatives of it, in a crystalline form. A brief summary of the physiological effects of both alkaloids as established in the scientific department of the chemical works of Messrs. E. Merck, of Darmstadt, Germany, is also given.

(*a*) "An Illustrated Analysis of Prehistoric Rock-Paintings from Pelzer's Rust. (*b*) A Rare Point from Sheppard Island," by C. VAN RIET LOWE.

"Crystals from the Kimberley Mines," by E. D. MOUNTAIN.

B. F. J. SCHONLAND,
Hon. General Secretary.

An Ordinary Meeting of the Society was held on Wednesday, June 17, 1931, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. W. A. JOLLY, was in the Chair.

Business:—

The Minutes of the Ordinary Meeting held on May 20 were confirmed.

M. A. POCOCK, B.Sc., G. M. DREOSTI, D.Sc., and E. A. GRIFFITHS, M.Sc., were elected to Membership of the Society.

The President intimated that he had nominated Professor A. OGG and Professor R. B. YOUNG as Vice-Presidents for the year 1931.

The Hon. General Secretary announced that the following had been nominated as Candidates for Fellowship of the Society:—J. H. POWER, F.Z.S., proposed by A. L. DU TOIT, S. H. HAUGHTON, Sir CARRUTHERS BEATTIE, J. HEWITT; A. J. T. JANSE, D.Sc., F.E.S., proposed by A. W. ROGERS, A. L. HALL, J. S. VAN DER LINGEN, E. P. PHILLIPS, C. P. LOUNSBURY.

Communications:—

"South African May-Flies," by K. H. BARNARD.

"Freshwater Algae and Phytoplankton from the Transvaal," by GUNNAR NYGAARD (communicated by Miss E. L. STEPHENS).

The algae dealt with in this paper were supplied by the late Professor Moss, and came chiefly from pans and stream-fed dams in the Transvaal. The phytoplankton of these was found to be, in general, a typical pond plankton, with *Microcystis aeruginosa* and *Botyococcus Braunii* sometimes becoming dominant. That of the larger river-dams was often dominated by the diatom *Melosira* which West found to be the chief form in Lake Nyassa. Both lakes and pans appear to be rather poor in species of algae, only 98 species and varieties being found in the samples, of which 6 species and 5 varieties are new. Two noteworthy finds were *Draparnaldia Ravenelii*, a species not found since 1887, when it was described from North America, and a new Coscinodiscus, *C. incomptus*, a freshwater species of this otherwise typically marine genus.

"Phytoplankton from South African Pans and Vleis," by F. RICH (communicated by Miss E. L. STEPHENS).

This paper deals with a collection of 38 samples of phytoplankton from various localities in the Union and Portuguese East Africa, chiefly from the Transvaal. Most of the samples were collected by Mr. and Mrs. Hutchinson while engaged in a general study of South African plankton. 262 species and varieties were found in this collection, among which were 9 new species and 8 new varieties, as well as several new forms. The occurrence of *Pleodorina californica* is interesting, for this genus had not

been recorded for South Africa. The marked differences found in the plankton from various bodies of water is noteworthy, suggesting that an interesting correlation of this with the chemical and physical characters of the water could be made by collectors in South Africa.

"The South African Guano Islands," by E. L. Gill.

"Note on a Special Hermitian Determinant," by Sir Thomas Muir.

"Phacochoerus Molars from South Africa," by T. F. Dreyer.

B. F. J. Schonland,
Hon. General Secretary.

An Ordinary Meeting of the Society was held on Wednesday, July 15, 1931, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

Dr. A. Ogg, Vice-President, was in the Chair.

Business:—

The Minutes of the Ordinary Meeting held on June 17 were confirmed.

Communications:—

"The Influence of Fluoride Ions upon the Reduction of Potassium Permanganate. Part I.—Reduction with Antimonious Salts," by W. Pugh.

In an attempt to overcome the difficulty of the fading of the end point in the estimation of antimony by the permanganate method, the effect of potassium fluoride was investigated. The consumption of permanganate increased by 25 per cent., and the solutions developed colours characteristic of manganic ion. The end point was, however, sharply distinguishable. The influence of varying concentrations of fluoride and of sulphuric, hydrochloric, nitric, and acetic acids was determined. The conclusion arrived at is that potassium permanganate is reduced to trivalent manganese except when high concentrations of hydrochloric acid are employed.

"The Bushmen-Hottentot-Strandlooper Tangle," by T. F. Dreyer.

"Contributions to a Knowledge of the Transvaal Iridaceae, Part II," by N. E. Brown (communicated by J. Burtt-Davy).

"Decomposition of Guano," by P. R. van der R. Copeman and F. J. Dillman.

The composition of guano from South African sources is studied and the possible causes of variation are discussed.

During storage in an air-dry condition there is a loss of total nitrogen due to the loss of ammonia from the guano.

In a moist condition the uric acid in guano becomes converted into ammonium compounds, and on subsequent drying there is an increased loss of nitrogen as compared with samples which have been kept in an air-dry state.

"The Antimony Electrode as a Means for *pH* Measurements," by A. C. LEEMAN.

The antimony electrode was tested on various buffers and soil solutions under controllable temperature conditions. It has been found that the potentials are not reproducible, showing a constant drift and extraordinary differences in potential when the same liquid is tested on different days.

The use of the electrode cannot be advocated either for soils or for any other of the solutions tested.

B. F. J. SCHONLAND,
Hon. General Secretary.

An Ordinary Meeting of the Society was held on Wednesday, August 19, 1931, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

Dr. A. OGG, Vice-President, was in the Chair.

Business:—

The Minutes of the Meeting held on July 15 were confirmed.

EILEEN M. RADLOFF, B.Sc., Ph.D., proposed by Miss M. WILMAN, seconded by J. H. POWER; ELAINE M. YOUNG, M.Sc., Ph.D., proposed by Miss E. L. STEPHENS, seconded by the Hon. General Secretary; JOHANNA F. SCHUURMAN, M.A., proposed by Miss E. L. STEPHENS, seconded by A. ZOOND, were nominated to Membership.

Communications:—

"The Genus *Anthephora*, Schreb.," by A. P. GOOSSENS (communicated by E. P. PHILLIPS).

"The Great Barrier Reef Expedition of 1928–1929," by T. A. STEPHENSON.

B. F. J. SCHONLAND,
Hon. General Secretary.

Annual Meeting.

The Annual Meeting of the Society for the Election of Fellows was held on Wednesday, September 23, 1931, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

Dr. A. Ogg, Vice-President, was in the Chair.

Business:—

The following Candidates were elected Fellows of the Society:—A. J. T. Janse, D.Sc., F.E.S.; J. H. Power, F.Z.S.

Ordinary Meeting.

An Ordinary Meeting was held after the Annual Meeting.

Dr. A. Ogg, Vice-President, was in the Chair.

Business:—

The Minutes of the Ordinary Meeting held on August 19 were confirmed.

Eileen M. Radloff, B.Sc., Ph.D.; Elaine M. Young, M.Sc., Ph.D.; Johanna F. Schuurman, M.A., were elected to Membership.

Communications:—

"The Histology of the Adrenal Glands of Xenopus," by H. Zwarenstein and I. Schrire.

"High Temperature Absorption Spectra," by D. J. Malan (communicated by A. Ogg).

R. S. Adamson,
Acting Hon. General Secretary.

An Ordinary Meeting of the Society was held on Wednesday, October 21, 1931, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

Dr. A. Ogg, Vice-President, was in the Chair.

Business:—

The Minutes of the Annual Meeting and of the Ordinary Meeting held on September 23, 1931, were confirmed.

The Vice-President gave notice of the Anniversary Meeting and announced that the following were recommended by the Council for election as Council and Officers for 1932:—

President, Dr. W. A. Jolly; Treasurer, Dr. L. Crawford; Secretary, Dr. B. F. J. Schonland; Members of Council, Dr. K. H. Barnard, Dr. J. Bews, Professor A. Brown, Dr. P. J. du Toit, Mr. A. J. H. Goodwin, Dr. H. Spencer Jones, Sir Spencer Lister, Dr. A. Ogg, Dr. B. St. J. van der Riet.

Communications:—

"The Glaciated Surfaces of Nooitgedacht, near Kimberley, and the Upper Dwyka Boulder Shales of the Eastern Part of Griqualand West (Cape Province)," by G. Slater (communicated by S. H. Haughton).

The evidence in Griqualand West contributes notably to our knowledge of glacial erosion and sedimentation.

1. *Nooitgedacht* is a classical area for the study of progressive erosion of the topographical features by land-ice. The rock basin contains large outcrops of jointed diabase which display excellent examples of crag and tail phenomena showing in plan the stream-line form. In each case the iceward limb is characterised by striations, polishing, grooves, shelves, chatter-marks, and relief polishing where amygdaloids occur, the surface having formed the lubricated sole of a thrust-plane for ice which functioned as a soft abrasive. The iceward limb increases in length with progressive decrease in height of the obstruction to ice-movement, and terminates at the crest of a sigmoid curve. Abrasion was therefore the dominant form of erosion in the later stages of ice action. The leeward limb is associated with "pluck," more especially in the larger outcrops. This type of erosion characterises the earlier stages of ice action.

2. *De Kalk*.—The section at De Kalk is a type example of the sedimentation of glacial detritus in water. The hard bands of tillite-like material represent englacial substance from land-ice which has been deposited as cakes from floating ice. With rapid deposition the structure has remained intact; with slower deposition disintegration is shown by incipient layering and the precipitation of the oval-shaped pellets now seen in the ground-mass.

"A Seasonal Study of the Micro-Flora and Micro-Fauna of Florida Lake, Johannesburg," by Johanna F. Schuurman.

"The Parasitism of *Harveya speciosa*, Bernh.," by Elaine M. Young.

"The Stability of Bromic Acid and its Use in Determining Traces of Bromine in Bromates and in Chlorides," by W. Pugh.

"Germanium. Part X.—Aqueous Solutions of Sodium Germanate: Heterogeneous Equilibria and Electrical Conductivity," by W. Pugh.

"The Flora of Kroonstad," by J. W. Pont.

R. S. Adamson,
Acting Hon. General Secretary.

ANNIVERSARY MEETING.

The Anniversary Meeting of the Society was held on Wednesday, March 16, 1932, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. W. A. JOLLY, was in the Chair.

Business:—

The report of the Hon. General Secretary for the year 1931 was read and adopted.

The report of the Hon. Treasurer for the year 1931 was read and adopted.

The following were elected as Officers and Council for the year 1932:—

President, Dr. W. A. JOLLY; Hon. Treasurer, Dr. L. CRAWFORD; Hon. General Secretary, Dr. B. F. J. SCHONLAND; Members, Dr. K. H. BARNARD, Dr. J. W. BEWS, Professor A. BROWN, Dr. P. J. DU TOIT, Mr. A. J. H. GOODWIN, Dr. H. SPENCER JONES, Sir SPENCER LISTER, Dr. A. OGG, Dr. B. ST. J. VAN DER RIET.

The President delivered an address on "The Living Organism."

The views expressed by some recent writers on modern physics suggest that physical and chemical conceptions are only a kind of shorthand useful for describing sensory phenomena. We are forced to the conclusion that physiological knowledge is the ultimate aim and object of all science.

If we are ever to attain to self-knowledge, to explain ourselves, and to determine our place in nature and our relation to the world around, it is to advance in Biology that we must trust. All that we know of the Universe is due to physiological changes of some kind.

In the living organism, regarded as a whole, we have a phenomenon whose unity and fundamental nature are as essential as any of the concepts of Physics. It is wrong to think that life can ever be explained in terms of present-day Chemistry and Physics. Some reorientation in the public attitude to Science and in scientific education is necessary to prevent a dangerous one-sidedness in our civilisation. Psychology, studied by subjective methods, working in collaboration with Physiology, has an important part to play in our final achievement of self-knowledge.

The address concluded with an account of the methods and difficulties of modern physiological research, with special reference to Electrophysiology and the time-relations of the simple reflex.

ORDINARY MEETING.

The Anniversary Meeting was followed by an Ordinary Meeting.

The President, Dr. W. A. JOLLY, was in the Chair.

Business:—

The Minutes of the Ordinary Meeting held on October 21, 1931, were confirmed.

W. H. CRAIB, M.C., M.B., Ch.B., F.R.C.P., proposed by Dr. A. OGG; N. SMITH, M.A., D.Sc., proposed by Dr. W. F. BARKER; S. M. NAUDÉ, M.A., Ph.D., proposed by Dr. A. OGG; A. P. GOOSSENS, M.Sc., proposed by Dr. E. P. PHILLIPS; R. E. HELME, proposed by Mr. A. J. H. GOODWIN (all seconded by the Hon. General Secretary), were nominated to Membership.

Communications:—

"On Pollen from the Upper Cretaceous Dysodil of Banke, Namaqualand," by F. KIRCHHEIMER, Giessen (communicated by Dr. S. H. HAUGHTON).

Pollen forms, belonging to Conifers and Angiospernes, are described from a dysodil, probably of Upper Cretaceous Age, from Namaqualand. Although they do not permit of exact morphologic comparison with the pollen of recent plants, there is, at present, no doubt as to their close affinity. They do not in the least agree with the present-day flora of the area. This serves to show, in conjunction with the character of the megascopic plant remains, that the ecological character of the area at the time of formation of the deposits was widely different from that of to-day.

"The Composition of the Deeper Sediments of the Pipe at Banke, Namaqualand, and their Relation to Kimberlite," by E. REUNING.

A brief account is given of the chemical composition and microscopic characters of dysodil from the Banke pipe. It is shown that the various rocks known found in the neighbourhood—granite, dolerite, and Karroo sediments—can have contributed but little to the composition of the dysodil. Comparison of the composition and the Niggli-values with those of Kimberlite and melitite-basalt leads to the conclusion that the dysodil is the product of the infilling of the pipe by finest mud obtained from the weathering of ejected Kimberlite material that was lying on the granite in the neighbourhood of the pipe. An explanation is also offered for the present-day distribution of diamonds in Namaqualand.

"On some South African Fossil Proboscidea," by S. H. HAUGHTON.

This paper describes certain new proboscidean remains which are attributed to the genera *Archidiskodon* and *Pilgrimia*, and produces evidence of considerable dental variability within the confines of a single living race of African elephant.

The geology of the various gravels of the Vaal River area is critically examined; the possibility that the gravels of the so-called "Middle Terrace"

and the "River-bed gravels" may be contemporaneous is discussed; and the necessity for more detailed geological examination of certain critical areas is urged.

"South African Graminae," by A. P. GOOSSENS (communicated by Dr. E. P. PHILLIPS).

(*a*) "Note on Sets of Orthogonally related Variables. (*b*) A Second Note on the Coevanescence of Primary Minors of an Axisymmetric Determinant," by Sir THOMAS MUIR.

"South African Ancylidae," by F. G. Cawston.

"A Genetic Study of the Vertebral Column of the Griquas," by V. H. BRINK.

B. F. J. SCHONLAND,
Hon. General Secretary.

REPORT OF THE HON. GENERAL SECRETARY FOR 1931.

Eight Ordinary Meetings, the Annual Meeting, and the Anniversary Meeting were held during the year, and the undermentioned papers were read:—

1. "The Ancient Iron-Smelting Cavern at Mumbwa," by R. A. DART and NINO DEL GRANDE.

2. "On a New Species of Aristea," by R. S. ADAMSON.

3. "The Effect of Castration upon Protein Metabolism," by H. ZWARENSTEIN and I. SCHRIRE.

4. "Perceptual Tests of General Intelligence for International Use," by M. FORTES.

5. (*a*) "Note on Equalities connecting Two Sums of Squares. (*b*) Note on a Special Alternant of Three Variables," by Sir THOMAS MUIR.

6. "A Sketch of the Floral Regions of Tanganyika Territory," by J. F. V. PHILLIPS.

7. "Vesalius on Vivisection," by B. FARRINGTON.

8. "On the Herpetological Fauna of the Lobatsi-Linokana Area," by J. H. POWER.

9. "Western Mediterranean Parallels with the Stone Age in South Africa," by A. J. H. GOODWIN.

10. "Tissue Respiration in Relation to the Physiology of Infection," by W. CAMPBELL and W. GERSHOLOWITZ.

11. "The Reaction of Xenopus to Digitalis," by J. W. C. GUNN and D. EPSTEIN.

12. "The Adrenal Secretion of *Xenopus laevis*," by D. EPSTEIN, J. W. C. GUNN, E. EPSTEIN, and G. RIMER.

13. "South African Bryophyta: Further Notes," by T. R. SIM.

14. "Correlations between the Field Changes due to Lightning and the Appearance of the Flashes," by E. L. HALLIDAY.

15. "Point Discharge Measurements below Thunderstorms," by B. F. J. SCHONLAND and C. A. COPPENS.

16. "The Alkaloids of the Bark of *Strychnos Henningsii*," by M. RINDL (second communication).

17. (*a*) "An Illustrated Analysis of Prehistoric Rock-Painting from Pelzer's Ruse. (*b*) A Rare Point from Sheppard Island," by C. VAN RIET LOWE.

18. "Crystals from the Kimberley Mines," by E. D. MOUNTAIN.

19. "South African May-Flies," by K. H. BARNARD.

20. "Freshwater Algae and Phytoplankton from the Transvaal," by GUNNAR NYGAARD (communicated by Miss E. L. STEPHENS).

21. "Phytoplankton from South African Pans and Vleis," by F. RICH (communicated by Miss E. L. STEPHENS).

22. "The South African Guano Islands," by E. L. GILL.

23. "Note on a Special Hermitian Determinant," by Sir THOMAS MUIR.

24. "Phacochoerus Molars from South Africa," by T. F. DREYER.

25. "The Influence of Fluoride Ions upon the Reduction of Potassium Permanganate. Part I.—Reduction with Antimonious Salts," by W. PUGH.

26. "The Bushman-Hottentot-Strandlooper Tangle," by T. F. DREYER.

27. "Contributions to a Knowledge of the Transvaal Iridaceae, Part II," by N. E. BROWN (communicated by J. BURTT-DAVY).

28. "Decomposition of Guano," by P. R. VAN DER R. COPEMAN and F. J. DILLMAN.

29. "The Antimony Electrode as a Means for *pH* Measurements," by A. C. LEEMAN.

30. "The Genus *Anthephora*, Schreb.," by A. P. GOOSSENS (communicated by E. P. PHILLIPS).

31. "The Great Barrier Reef Expedition of 1928–1929," by T. A. STEPHENSON.

32. "The Histology of the Adrenal Glands of Xenopus," by H. ZWARENSTEIN and I. SCHRIRE.

33. "High Temperature Absorption Spectra," by D. J. MALAN (communicated by A. OGG).

34. "The Glaciated Surfaces of Nooitgedacht, near Kimberley, and the Upper Dwyka Boulder Shales of the Eastern Part of Griqualand West (Cape Province)," by G. SLATER (communicated by S. H. HAUGHTON).

35. "A Seasonal Study of the Micro-Flora and Micro-Fauna of Florida Lake, Johannesburg," by JOHANNA F. SCHUURMAN.

36. "The Parasitism of *Harveya speciosa*, Bernh.," by ELAINE M. YOUNG.

37. "The Stability of Bromic Acid and its Use in Determining Traces of Bromine in Bromates and in Chlorides," by W. Pugh.

38. "Germanium. Part X.—Aqueous Solutions of Sodium Germanate: Heterogeneous Equilibra and Electrical Conductivity," by W. Pugh.

39. "The Flora of Kroonstad," by J. W. Pont.

Vol. XIX., parts 2, 3, and 4, and Vol. XX., part 1, of the Society's Transactions have been issued during the year.

A. J. T. Janse, D.Sc., F.E.S., and J. H. Power, F.Z.S., were elected Fellows of the Society in 1931.

Ten new Members were elected during the year, and one former Member rejoined.

At the end of 1931 the number of Honorary Fellows was 1, Fellows 69, Members 143.

The deaths since the 1931 Anniversary Meeting of Dr. R. Marloth and Professor William Ritchie are recorded with regret.

During the year nine Members resigned, and the names of three Members were struck off the list.

At the Ordinary Meeting on May 20, 1931, on the invitation of the Council, Dr. S. H. Haughton delivered a lecture before the Society on "The Geological History of the South Atlantic Ocean."

During the year the Society's Library was removed to the Jagger Library Building of the University of Cape Town, where it is housed as a separate unit under the University Librarian.

The following gift was received by the Library during 1931:—

From the authors, New Fossil Mammals and Man from South Africa, by T. F. Dreyer and Alice Lyle.

The exchanges with the Library have been maintained, and a new exchange arranged with the following institution:—Kung. Universitetets Bibliotek, Upsala.

842 cards were sent to the International Catalogue of Scientific Literature by Dr. K. H. Barnard.

358 volumes of periodicals have been sent for binding during the year.

The following represented the Society as delegates to Centenary Meetings overseas:—The British Association and the Faraday Centenaries, the President; the Clerk Maxwell Centenary, the Hon. Secretary.

A deputation from the Council waited upon the Minister for Education and discussed with him the question of the Government grant to the Society, which had been reduced to £50 from £300. The Minister promised to consider the matter on the Supplementary Estimates. He has since informed the Council that the financial situation makes it necessary for him to withdraw the grant for 1932 altogether.

B. F. J. Schonland,
Hon. General Secretary.

REVENUE AND EXPENDITURE ACCOUNT FOR THE YEAR ENDING DECEMBER 31, 1931.

REVENUE AND EXPENDITURE ACCOUNT FOR THE YEAR ENDING DECEMBER 31, 1931.

Revenue.

	£ s. d.	£ s. d.
To Subscriptions collected for 1931 :—		
Subscriptions collected for years before 1929	3 0 0	
„ „ 1929	4 0 0	
„ „ 1930	33 0 0	
„ „ 1931	275 7 0	
„ „ 1932	9 2 0	
„ collected in advance for 1931	2 17 0	
„ Outstanding Subscriptions at December 31, 1931	52 13 0	
	379 19 0	
Less: Outstanding Subscriptions as in Statement, December 31, 1930, £55, 15s.; Subscriptions collected in 1931 for 1932, £9, 2s.	64 17 0	
		315 2 0
„ Entrance Fees		10 0 0
„ Government Grant		50 0 0
„ Interest received :—		
On Fixed Deposit, £350, at Standard Bank for one year at 5 per cent.	17 10 0	
On £408 New Union of South Africa 5 per cent. Stock	20 8 0	
On Money in Savings Bank Department of Standard Bank	7 18 0	
		45 16 0
„ Sale of Publications in 1931	64 11 0	
Less: Money spent in purchase of Parts ..	3 5 4	
	61 5 8	
Plus: Amount due for Sales in 1931 ..	17 3 6	
	78 9 2	
Less: 1930 Accounts paid in 1931 £2 14 1; 1932 Account paid in 1931 0 18 9	3 12 10	
		74 16 4
„ Sale of Copies of Bushman Painting		0 10 0
„ Loss in year 1931		315 7 7
		£811 11 11

Expenditure.

	£ s. d.	£ s. d.	£ s. d.
By Publications :—			
Cash Paid to Messrs. Neill & Co. for Printing, etc. ..		538 4 6	
Less: Exchange		30 7 7	
		507 16 11	
Cost of Bank Drafts		2 19 3	
		510 16 2	
Less: Receipts for extra Reprints of Papers	40 12 2		
Amount due for Sales in 1931	7 17 0		
Payment for half cost of blocks (Goodwin) ..	3 19 0		
	52 8 2		
Less: 1930 Account paid in 1931	1 10 0		
		50 18 2	
		459 18 0	
Plus: Amount due for Printing, etc., Vol. XX., Part 1		118 1 8	
			577 19 8
„ Compilation of International Catalogue of Scientific Papers			16 16 0
„ Clerical Assistance and Work in Library ..			84 0 0
„ Expenses *re* removal of Library to Groot Schurr			9 13 0
„ Local Printing and Stationery		48 9 6	
Less: Amount received for Reprints of Minutes		1 13 9	
			46 15 9
„ Postages and Petties			19 15 2
„ Binding			41 17 0
„ Bank Charges for Commissions, Ledger Fees, Fixed Deposit Stamps, etc. ..		4 14 0	
Less: Commissions paid by Members ..		2 2 2	
			2 11 10
„ Hire of Rooms and Caretaker			6 6 0
„ Insurance of back Numbers with Neill & Co.			0 17 6
„ Epidiascope Cupboard			5 0 0
			£811 11 11

ASSETS AND LIABILITIES AS AT DECEMBER 31, 1931.

Assets.*	£	s.	d.	Liabilities.	£	s.	d.
Money at Standard Bank on Fixed Deposit for one year at 4 per cent.	200	0	0	Subscriptions received in 1931 for 1932	9	2	0
Money in Savings Bank Department of Standard Bank	158	11	3	Amount received in advance for Sale of Publications	0	18	9
Balance at Standard Bank, as per Pass Book	47	6	8	Amount owing for Printing, etc., Vol. XX, Part 1, issued in 1931	118	1	8
Union of South Africa £408 5 per cent. Stock, 1929/39, reckoned at purchase price	400	0	0	Excess of Assets over Liabilities:— Amount at December 31, 1930 .. £1070 16 7; Less: Loss in 1931 .. 315 7 7	755	9	0
Arrears of Subscriptions, as in Statement for 1930, £55 15s.; less £35 paid in 1931 and £8 struck off as irrecoverable	12	15	0				
Arrears of Subscriptions for 1931, less £3 struck off as irrecoverable	39	18	0				
Amount due for Sale of Publications in 1931	17	3	6				
Amount due for Sale of Extra Reprints in 1931	7	17	0				
	£883	11	5		£883	11	5

* Exclusive of value of Library and Publications of the Society held in Stock.

Entrance Fees and Life Subscriptions Fund.

	£	s.	d.		£	s.	d.
Amount of Fund at January 1, 1931	426	0	0	Amount of Fund at December 31, 1931	436	0	0
Entrance Fees received in 1931	10	0	0				
	£436	0	0		£436	0	0

We hereby certify that we have examined the above accounts of Revenue and Expenditure, and of Assets and Liabilities, with the books, vouchers, and other documents and securities relating thereto, and that, in our opinion, these accounts set forth a correct statement of the affairs of the Society.

B. J. RYRIE.
J. W. C. GUNN.

February 9, 1932.

Ordinary Meeting.

An Ordinary Meeting of the Society was held on Wednesday, April 20, 1932, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. W. A. Jolly, was in the Chair.

Business:—

The Minutes of the Ordinary Meeting held on March 16, 1932, were confirmed.

W. H. Craib, M.C., M.B., Ch.B., F.R.C.P., proposed by Dr. A. Ogg; N. Smith, M.A., D.Sc., proposed by Dr. W. F. Barker; S. M. Naudé, M.Sc., Ph.D., proposed by Dr. A. Ogg; A. P. Goossens, M.Sc., proposed by Dr. E. P. Phillips; R. E. Helme, proposed by Mr. A. J. H. Goodwin (all seconded by the Hon. General Secretary), were elected Members of the Society.

Communications:—

"The Spectroscopic Determination of Isotopes," by S. M. Naudé.

A brief discussion of the spectroscopic determination of isotopes was given. The determination from line spectra is limited to the lighter elements, the recent discovery of the hydrogen isotope of atomic weight 2 serving as an example. Molecular spectra offer a much greater opportunity for the discovery of isotopes, since the mass of the constituent atoms of the molecule enters directly in the expressions for the vibrational and rotational energy of the molecule. As an example, the discovery by the author of the nitrogen isotope of atomic weight 15 from the nitrogen oxide spectrum, as well as the work on the oxygen isotopes of atomic weights 17 and 18 and the carbon isotope, 13, was discussed. The importance of this work was pointed out, the existence of an isotope providing evidence that the corresponding configuration of electrons and protons in the nucleus must be stable. Any ultimate theory of the atomic nucleus will have to explain the existence or non-existence of any atomic species.

"A Penetrating Radiation from Thunderclouds," by B. F. J. Schonland and J. P. T. Viljoen.

Experiments have been made during the past summer using a Geiger-Muller counter to record the ionising particles from the penetrating rays upon the tape of an electric chronograph. Another pen marked the occurrence of lightning flashes.

Overhead thunderstorms showed the screening effect found in previous work (Proc. Roy. Soc., A, vol. cxxx, p. 37, 1930) as a large reduction in the number of counter impulses before an overhead flash occurred.

The records show a marked tendency for counter-kicks to coincide in time with distant lightning flashes. The number of such coincidences was sometimes ten times as great as that calculated to be due to chance.

Tests seemed to preclude the possibility that these coincidences arose from any mutual action of the counter and the atmospheric recorder.

It appears that a penetrating radiation capable of passing through a considerable thickness of iron is generated by a thunderstorm at the moment a lightning flash occurs. The records show also that a small amount of this radiation is generated before the discharge.

"An Account of the Discovery, Exploration, and Archaeology of the Matjes River Rock Shelter," by T. F. Dreyer.

"A Descriptive Account of the Human Skulls from the Matjes River Cave, Cape Province," by Sir Arthur Keith.

"An Outline Investigation of the Essential Oil of *Pteronia stricta* Ait.," by J. L. B. Smith and M. L. Sapiro.

"A Contribution to the Chemistry of *Rauwolfia natalensis*," by M. Rindl and P. W. G. Groenwoud.

The bark of the so-called "quinine tree" (Koorsboom) is credited with possessing medicinal virtues. In South Africa three species belonging to the Natural Order Apocynaceae are included under this name: *Rauwolfia natalensis*, *Voacanga dregei*, and *Conopharyngia ventricosa* (*Tabernaemontana ventricosa*). In the Report of the Senior Government Analyst (Cape of Good Hope) for 1901, p. 58, the isolation of a crystalline alkaloid from the bark of the quinine tree is recorded. The botanical identity of the plant on which this investigation was carried out is doubtful. In an endeavour to establish the identity of the bark used and to corroborate the results recorded in the Analyst's Report a cursory investigation of the bark of the three trees enumerated above was carried out by the authors. All three contain several alkaloids, at least one of which in each case gives a fluorescent solution. But the alkaloids do not appear to be identical. Not more than traces of crystalline products were obtained, and in no case could anything be isolated which even remotely resembled the alkaloid recorded in the earlier literature. The bark of *Rauwolfia natalensis* was thereupon subjected to a searching investigation. The cold alcoholic percolate furnishes (*a*) cane sugar; (*b*) an amorphous yellow alkaloid which, when administered orally or subcutaneously to cats in doses of 27 mg. per kg. body weight, causes an elevation of temperature. This result is interesting inasmuch as the local name and reputed use of the bark suggested that it would have an antipyretic effect. The alkaloid has no definite melting-point, and it resisted all attempts to obtain it or one of its derivatives in crystalline form. It is obtained by fractional precipitation of the aqueous solution with sodium carbonate.

(*c*) An amorphous alkaloid extracted from the aqueous alkaline solution with ether and giving the Rauwolfine reaction with concentrated nitric acid. This reaction is stated to be characteristic of the crystalline alkaloid which occurs in several tropical *Rauwolfia* species.

(*d*) An amorphous alkaloid extracted from the aqueous alkaline solution with ethyl acetate and giving a fluorescent solution. This alkaloid does not give the Rauwolfine reaction.

(*e*) One or more alkaloids which appear to be very soluble in water and are not removed from the aqueous alkaline solution by shaking with immiscible solvents.

As cold extraction failed to exhaust the bark, continuous hot percolation with alcohol in a large copper Soxhlet was resorted to. In the absence of any well-defined products it is difficult to say whether, and to what extent, the products so obtained differ qualitatively from those obtained by cold percolation. The only definite difference which it is possible to record at this stage is the extraction by *ethyl acetate* of a substance giving the Rauwolfine reaction. In the case of the cold percolation a product answering to this test was obtained only from the ether extract.

The Vitali reaction which was described as characteristic of the alkaloid isolated in the earliest investigation recorded in the annual report of the Government Analyst was found to be given by quite a number of extracts obtained with different solvents.

B. F. J. SCHONLAND,
Hon. General Secretary.

An Ordinary Meeting of the Society was held on Wednesday, May 18, 1932, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. W. A. JOLLY, was in the Chair.

Business:—

The Minutes of the Ordinary Meeting held on April 20, 1932, were confirmed.

H. STEPHEN, O.B.E., M.Sc., F.C.S., proposed by Dr. J. P. DALTON, seconded by Professor H. PAINE; D. EPSTEIN, M.A., Ch.B., Ph.D., proposed by the President, seconded by the Hon. General Secretary, were nominated to Membership of the Society.

The Hon. Secretary announced that the following had been nominated as Candidates for Fellowship of the Society:—

DORA F. BLEEK, proposed by E. L. GILL, S. H. HAUGHTON, E. L. STEPHENS, and M. R. LEVYNS; JOHN F. V. PHILLIPS, D.Sc., F.R.S.E.,

F.L.S., proposed by J. P. Dalton, H. H. Paine, R. B. Young, R. A. Dart, H. B. Fantham; Jan Christian Smuts, C.H., P.C., LL.D., D.Sc., proposed by H. A. Reyburn, Sir J. Carruthers Beattie, A. Young, R. H. Compton, H. Bohle, E. Newbery, J. Smeath Thomas; Henry Stephen, O.B.E., D.Sc., F.C.S., proposed by J. P. Dalton, H. H. Paine, R. B. Young, R. A. Dart, H. B. Fantham.

Communications:—

"Fossil Wood from Fort Grey," by R. S. Adamson.

"Reproduction in Volvox," by M. A. Pocock.

"Contributions to the Flora of the Knysna and Neighbouring Divisions," by H. G. Fourcade.

In preparing a list of the flowering plants found in the divisions of George, Knysna, Humansdorp, and Uniondale, based chiefly on his own collections at intervals during many years, the author wished to include the new species collected by himself that were still undescribed, and with this object has supplied their description in the paper. He has added the name changes in his list that have been rendered necessary by the international rules of botanical nomenclature. In testing the numerous new combinations that have already been made by others since the publication of the Flora Capensis a number of illegitimate changes were found, and these are rectified whenever they relate to species included in the compiled list.

"On Placocystella, a New Genus of Cystids from the Lower Devonian of South Africa," by J. V. L. Rennie.

"A Case of Inverted Polarity in Nature," by J. W. Pont.

B. F. J. Schonland,
Hon. General Secretary.

An Ordinary Meeting of the Society was held on Wednesday, June 15, 1932, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. W. A. Jolly, was in the Chair.

Business:—

The Minutes of the Ordinary Meeting held on May 18, 1932, were confirmed.

H. Stephen, O.B.E., D.Sc., F.C.S., and D. Epstein, M.B., Ch.B., Ph.D., were elected to Membership of the Society.

Communications:—

"The Action of Histamine on the Respiratory Passages," by D. Epstein.

A method was described by which the effects of drugs on the isolated trachea and bronchi of small animals can be recorded with a magnification

of about 200 times. Using this method it was found that histamine produces powerful constriction of the trachea and bronchi of the guinea-pig, but has no effect on or relaxes these structures in the cat. As a result of other methods of investigation it was concluded that histamine produces obstruction of the air passages of the guinea-pig by a direct constrictor effect on the musculature of the trachea, bronchi and probably bronchioles, while in the cat the respiratory obstruction seen with this drug is due to a constriction limited to the bronchioles alone. On the basis of these results hypotheses have been put forward in an attempt to examine the respiratory reactions seen in anaphylaxis and asthma.

"The Effects of Hypophysectomy and Castration on Serum Calcium in *Xenopus laevis*," by H. A. SHAPIRO and H. ZWARENSTEIN.

The finding of Charles that removal of both lobes of the pituitary leads to a significant drop in serum calcium is confirmed.

Spontaneous partial atrophy of the ovaries in vlei females is found to be associated with a significant drop of 24 per cent.

Castration of vlei females gives the same fall in serum calcium as double hypophysectomy, *i.e.* about 40 per cent. This result can be detected as early as 11 weeks after the operation.

In males a slight rise of 7·6 per cent., which is not significant, is observed after removal of both lobes. Castration leads to a significant drop of 14·6 per cent.

It is probable that in females the drop after hypophysectomy is primarily due to ovarian atrophy.

"The Effect of Injections of Arginine and Histidine on Urinary Creatinine," by B. G. SHAPIRO and H. ZWARENSTEIN.

Injections of large doses of arginine or of histidine gives a 12–40 per cent. increase in urinary creatinine. Alanine has no effect. After injection of Locke's solution as a control the creatinine excretion was unaffected.

"Some Developments in Technique during the Earlier Stone Age," by A. J. H. GOODWIN.

It is suggested that the Lower Palaeolithic of Europe presents only the beginning and the end of a single technical development, which is better represented as a complete series in Africa; the morphological sequence in the development being this:

1. The use of a nodule or pebble for making the *coup-de-poing* (Abbeville technique).
2. The use of a flake struck from a river boulder.
3. The use of flakes struck from a rock fragment trimmed as a core (Tachengit technique).
4. The use of a specially prepared core from which only one useful flake was struck (Victoria West technique).

5. A development and refinement of 4 (Levallois technique).

Further developments are also suggested as being represented by the Mousterian and the Grand Pressigny techniques.

B. F. J. SCHONLAND,
Hon. General Secretary.

An Ordinary Meeting of the Society was held on Wednesday, July 20, 1932, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. W. A. JOLLY, was in the Chair.

Business:—

Confirmation of Minutes of the Ordinary Meeting held on June 15, 1932.

Communications:—

"A New Myctophid Fish from South Africa," by J. L. B. SMITH.

"Lightning Photographs by the Boy's Camera," by E. C. HALLIDAY.

"Floral Evolutionary Tendencies, Differentiation, and Distribution of the Labiatae in South Africa," by A. P. GOOSSENS.

"South African Gulellae," by H. J. PUZEY (communicated by Dr. F. G. CAWSTON).

"On the Existence of a Common Integrating Factor for a System of First Order Differential Equations," by F. UNDERWOOD (communicated by Dr. J. P. DALTON).

Dr. E. L. GILL exhibited a set of carved wooden pipes sent to the South African Museum by the Director of the Kimberley Museum. These showed remarkable ability on the part of an untaught native of Bushman descent.

B. F. J. SCHONLAND,
Hon. General Secretary.

An Ordinary Meeting of the Society was held on Wednesday, August 17, 1932, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. W. A. JOLLY, was in the Chair.

Business:—

The Minutes of the Ordinary Meeting held on July 20, 1932, were confirmed.

M. COGILL, B.A., B.Sc., proposed by Dr. F. G. CAWSTON, seconded by the Hon. General Secretary, was nominated to Membership.

Communications:—

"Electrolytic Rectifiers," by E. NEWBERY.

A short summary of observed anodic phenomena was given, together with an account of work recently published in Proc. Roy. Soc. Lond. It was shown that the theory proposed in a communication to this Society in 1929 (that the behaviour of a valve electrode could be accounted for by assuming the formation of a semi-permeable membrane on the surface) was fully justified by further investigation with the aid of the cathode ray oscillograph.

It was also shown that a valve electrode is capable of rectifying an alternating current only when the anodic membrane is not reducible by atomic hydrogen, and further that in the case of aluminium, the membrane consists of the oxide only and not the hydroxide.

"A Method of Measuring the Pressures on Oranges during and after the Process of Packing," by G. M. DREOSTI.

A method has been developed for the measurement of the total radial pressures upon oranges in different parts of a box of fruit, by substituting for the orange in question a bulb, with more or less the same physical properties as an orange, which is connected to a manometer outside the box. A tennis-ball, made up to the sizes of fruit, was used. The absolute values of the pressures registered depended upon the details of the particular apparatus used, but the relative values of the pressures were practically unaffected by changes in apparatus, and the method may be recommended for relative measurements.

The pressure upon an orange has been found to vary with the details of packing, *e.g.* repacking a box may alter the pressure on an orange by a factor about 1·5 (and probably more).

A few measurements of the change of pressure with time in a cold store indicate that the pressure falls roughly 0·35 per cent. per hour during the first hundred hours.

Making a few assumptions, simple formulae have been set up for the derivation of the forces between two oranges in contact (p) and between an orange and the faces of the box with which it is in contact (P). Using these formulae, estimates have been made of the values of p, of the order 0·75 kg., and P, generally over 1 kg., and very roughly the frictional forces between the oranges and the faces of the box, of the order 25 grams per sq. cm.

"Native Medicines in Natal," by F. G. CAWSTON.

An account is given of investigations into South African native and Indian herbal remedies used and sold in Natal for medicinal purposes.

"Note on a Set of Equivalent Determinants connected with a 3-by-6 Array," by Sir THOMAS MUIR.

"Protein Metabolism and the Effects of Injection of Testicular Extracts on Castrated Animals," by I. SCHRIRE and H. ZWARENSTEIN.

It has previously been shown that after castration there is a marked increase in creatinine excretion in male rabbits.

Following the injection of testicular extracts into castrated animals, there is a drop in the high creatinine excretion to precastration levels. This drop is only transient, and in a day or two after the injection the creatinine excretion is once more at the normal castration level.

B. F. J. SCHONLAND,
Hon. General Secretary.

ANNUAL MEETING.

The Annual Meeting of the Society for the Election of Fellows was held on Wednesday, September 21, 1932, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. W. A. JOLLY, was in the Chair.

Business:—

DORA F. BLEEK, JOHN F. V. PHILLIPS, D.Sc., F.R.S.E., F.L.S.; JAN CHRISTIAN SMUTS, C.H., P.C., LL.D., F.R.S.; and HENRY STEPHEN, O.B.E., D.Sc., F.C.S., were elected to Fellowship of the Society.

ORDINARY MEETING.

The Annual Meeting was followed by an Ordinary Meeting.

The President was in the Chair.

Business:—

The Minutes of the Ordinary Meeting held on August 17, 1932, were confirmed.

M. COGHILL, B.A., B.Sc., proposed by Dr. F. G. CAWSTON, seconded by the Hon. General Secretary, was elected a Member of the Society.

Communications:—

"New and Noteworthy South African Charophyta, II," by J. GROVES and E. L. STEPHENS.

This second instalment of notes includes descriptions and figures of nine new species, also figures of *N. plumosa* and *C. stachymorpha*, and a revision of the species which Braun included under *C. Kraussii* and *C. phaeochiton*.

"Repeated Conjugation in *Closterium pritchardianum*, Arch.," by E. D. LOSEBY (communicated by Miss E. L. STEPHENS).

Conjugation, following immediately on a period of rapid cell-division, occurred three times within a period of two months in a culture of this species. Each period of active reproduction lasted for about ten days, and there was a fortnight of quiescence between. Owing to the rapidity of successive divisions during each reproductive period, there were produced a certain number of individuals too small to conjugate. During the period of quiescence the species was represented by these undersized cells, and the subsequent recurrences of active reproduction occurred when they had reached mature size. Figures showing details of cell-division and conjugation are given.

"A Revision of *Lobostemon*, Lehm., and a Discussion on the Species Problem," by M. R. LEVYNS.

In the revision of *Lobostemon* it has been necessary to separate a small section as a new genus, *Echiostachys*.

Lobostemon, sensu stricto, is divided into five natural groups characterised by well-marked floral characters. Floral features are emphasised throughout. Vegetative characters are shown to be most variable, and therefore great caution must be observed in using them as diagnostic features. Twenty-eight species of *Lobostemon* and three species of *Echiostachys* are described.

The species problem is discussed, and Vavilov's law of homologous series in variation is shown to be applicable.

"The Mechanism of Projection of the Chameleon's Tongue," by A. ZOOND.

Experiments are described dealing with the muscles of the tongue and the hyoid apparatus, and with the lingual nerves, arteries, and veins. The results lead to the following conclusions:—

(1) The preliminary protrusion of the tongue is effected by the contraction of the geniohyoid muscles.

(2) When the tongue is held in the protruded position, the *hyoglossi* are in a state of extreme contraction, thus drawing the tongue knob right back on to the *processus entoglossus*, the end of which occupies the whole lumen of the tongue knob. At the same time the ring muscle of the tongue knob is strongly contracted, thus exercising an ejaculating thrust upon the end of the *processus*, which, however, is prevented from slipping out of the lumen of the tongue knob by the contracted state of the *hyoglossi*.

(3) At the instant of projection the *hyoglossi* relax, and the already existing tension of the ring muscle causes the *processus* to be thrown out of the lumen of the tongue knob. But the recoil of the *processus* is effectively prevented by the contracted state of the geniohyoids, thus resolving

the thrust of the tongue knob upon the *processus* into a force which projects the tongue violently forward.

(4) Retraction is effected by the simultaneous contraction of the *hyoglossi* and the sternohyoids; the former draw the tongue back on to the *processus*, and the latter return the hyoid apparatus and the tongue to their normal position of rest in the floor of the mouth.

"Note on the Skin-secreting Mechanism of *Xenopus laevis*," by H. A. SHAPIRO and L. P. BOSMAN.

The findings of HOGBEN, CHARLES, and SLOME, that removal of both lobes of the pituitary in Xenopus leads to a cessation of skin secretion in response to mechanical stimulation, are confirmed.

Attention is drawn to the fact that this phenomenon as a result of anterior lobe removal takes longer to occur.

That the mechanism involved in the skin-secreting response is vasomotor is unlikely in view of the fact that injections of histamine have no effect on the secreting reaction, while adrenaline produces a copious viscid secretion.

The hormones concerned with chromatic function in Xenopus have no influence on the skin-secreting mechanism.

Injections of "Pituitrin" (P. D. & Co.) have no effect on the skin responses of normal animals, but "Pituitrin" (P. D. & Co.) produces a profuse viscid white secretion, as also does destruction of the brain or cord by pithing.

Central nervous stimulants such as caffeine also produce the typical secreting response.

A chemical as well as a nervous factor may be involved in the total skin-secreting response of Xenopus.

"Protein Metabolism and the Effect of Injection of Pituitary Extracts on Normal and Castrated Animals," by I. SCHRIRE and H. ZWARENSTEIN.

Both anterior and posterior lobe extracts decrease the high creatinine excretion in castrated male rabbits almost to precastration levels. The effect on the normal rabbits is very slight.

"Herpetological Notes and Records.—I," by J. H. POWER.

"Sulphur as a Factor in the Corrosion of Iron and Steel Structures in the Sea," by W. J. COPENHAGEN.

The general theory of the submerged corrosion of ships is discussed. Observations on the film potential of twenty-one iron and steel structures gave a constant value of $-0{\cdot}3770$ volts (standard error $\pm{\cdot}0028$).

The presence of a primary and a secondary film on sea-water corroded iron and the significance of sulphur in the primary film are discussed, together with the occurrence of sulphur in corroded zinc plates on ships' bottoms and the possibility that the constant film potential is an iron

sulphide—CO_2 reaction. The time-potential of ships after cleaning and painting is given, and the time-potential curve of iron and steel in sea-water has been determined.

B. F. J. SCHONLAND,
Hon. General Secretary.

An Ordinary Meeting of the Society was held on Wednesday, October 19, 1932, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. W. A. JOLLY, was in the Chair.

Business:—

The Minutes of the Ordinary Meeting held on September 21, 1932, were confirmed.

The Hon. Secretary announced that the following had been selected for recommendation to the Society as Officers and Members of Council for the year 1933:—

President, Dr. W. A. ROGERS; Hon. Treasurer, Dr. L. CRAWFORD; Hon. General Secretary, Dr. B. F. J. SCHONLAND; Members of Council, Dr. J. W. BEWS, Professor A. BROWN, Dr. L. GILL, Dr. W. A. JOLLY, Sir SPENCER LISTER, Dr. A. OGG, Dr. P. VAN DER BIJL, Dr. J. S. VAN DER LINGEN, Professor R. B. YOUNG.

The Hon. Secretary gave notice that the following alteration in the Statutes would be put to the Society for its approval by ballot at the first Ordinary Meeting in 1933:—

Constitution of the Council.—To add, as Officers of the Society and as additional Members of Council, an Editor of the Transactions and a Librarian.

Communications:—

"The Intensity of Cosmic Radiation in South Africa," by S. M. NAUDÉ and J. E. C. COVENTRY.

The method of determining the intensity of cosmic rays was briefly described and the apparatus exhibited. The results obtained in July 1932 at eight different altitudes, ranging from sea-level (Cape Town) to 9200 feet (Mont-aux-Sources), show the usual increase of the intensity with the altitude, *i.e.* with the fall of the barometric pressure. The graph, intensity : barometric pressure, for South Africa (mean latitude 28° S.) lies between those representing Compton's determinations in New Zealand (42° S.) and at a point 4° S., thus verifying the dependence of the intensity on the latitude.

This work has been carried out as part of a world-wide survey of cosmic rays organised by Professor A. H. COMPTON, of Chicago.

"The Glucoside of *Gnidia Polycephala* (Januarie Bossie)," by M. RINDL.

"Preliminary Descriptions of New Species and New Records of Fishes from South Africa," by J. L. B. SMITH.

"The Kitchen-Middens at Gordon's Bay," by H. A. SHAPIRO.

The bored-stone would seem to be a late addition to the kitchen-midden or "Strandloper" culture. Pottery would seem to be late, and is not present in all the middens. Previous to the appearance of these two elements the culture produced only formless stone instruments, shaped by their use, and without intention. No formal flakes or implements appear. The middens seem to overlie natural dunes, and do not appear to be superposed over earlier deposits at this site. Two skeletons (the skulls having been removed some years before) were discovered. From Dr. D. SLOME'S description these would fall within the San race. An analysis of shell and bone refuse is given.

"The Influence of Fluorides on Reduction of Permanganates: Potentiometric Titrations," by W. PUGH.

"Excavations at Floris Bad: with Notes on a Human Skull Fragment," by T. F. DREYER.

LECTURE.—Professor A. OGG, M.A., Ph.D., F.Inst.P., delivered a lecture on "The Polar Year, 1932–1933." At the conclusion the President thanked the lecturer on behalf of the Society.

B. F. J. SCHONLAND,
Hon. General Secretary.

ANNIVERSARY MEETING.

The Anniversary Meeting of the Society was held on Wednesday, March 15, 1933, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. W. A. JOLLY, was in the Chair.

Business:—

The Reports of the Hon. General Secretary and Hon. Treasurer for the year 1932 were read and adopted.

The following were elected as Officers and Members of Council for the year 1933:—

President, Dr. A. W. ROGERS; Hon. Treasurer, Dr. L. CRAWFORD; Hon. General Secretary, Dr. B. F. J. SCHONLAND; Members of Council,

Dr. J. W. Bews, Professor A. Brown, Dr. L. Gill, Dr. W. A. Jolly, Sir Spencer Lister, Dr. A. Ogg, Dr. P. van der Bijl, Dr. J. S. van der Lingen, Professor R. B. Young.

Ordinary Meeting.

The Anniversary Meeting was followed by an Ordinary Meeting.

The President, Dr. A. W. Rogers, took the Chair.

Business:—

Professor A. Ogg expressed the thanks of the Society to the retiring President, Dr. W. A. Jolly, who had served as an executive officer, first as Secretary and then as President, for nineteen years.

The Minutes of the Meeting held on October 19, 1932, were confirmed.

General J. C. Smuts was admitted as a Fellow of the Society.

Communications:—

"The Class Enteropneusta, with special reference to the South African Species," by C. von Bonde.

"The Distribution of the Ionising Particles of the Penetrating Radiation with respect to the Magnetic Meridian," by J. P. T. Viljoen and B. F. J. Schonland.

An investigation of the direction of arrival of the ionising particles associated with the penetrating radiation has been made at sea-level in Cape Town (mag. lat. 31° S.). The numbers of particles from magnetic North, South, East, and West were compared by means of a coincidence counter.

The differences found were (1) North-South $0{\cdot}4 \pm 1{\cdot}5$ per cent., (2) West-East $1{\cdot}5 \pm 2{\cdot}6$ per cent., (3) North-West $2{\cdot}9 \pm 2{\cdot}6$ per cent., (4) North-East $4{\cdot}3 \pm 2{\cdot}6$ per cent.

It is concluded that any charged particles of extra-terrestrial origin are accompanied by a larger number of secondary particles generated in the atmosphere by some radiation which is not affected by the earth's magnetic field.

The North-East difference suggests that the majority of the primary particles are positively charged.

"Middle Stone Age Industries near Bloemfontein," by T. F. Dreyer.

B. F. J. Schonland,
Hon. General Secretary.

An Ordinary Meeting of the Society was held on Wednesday, April 19, 1933, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. W. A. Rogers, was in the Chair.

Business:—

The Minutes of the Anniversary and Ordinary Meetings held on March 15, 1933, were confirmed.

Communications:—

"Electrolytic Refining of Mercury," by E. Newbery and S. M. Naudé.

A method for the electrolytic purification of mercury is described, in which a mercurous perchlorate electrolyte is used with a cathode of pure mercury, an E.M.F. of 0·5 volts and a current density of about 1 ampere per square decimetre.

Two types of apparatus are described for use with and without mechanical stirring respectively. The chief difficulty encountered lies in the formation of crusts of solid salt over the exposed surface of the anode.

Spectroscopic examination of the product indicates that a high standard of purity is obtained by this process.

"*Nivenia*, Vent. and *Nivenia*, R. Br.," by N. E. Brown.

"A Revision of the Genus *Lopholaena* DC.," by E. P. Phillips and C. A. Smith.

"The Appearance and Spread of a *Senecio* rare to the Cape Peninsula," by M. R. Levyns.

A species of *Senecio* new to the Cape Peninsula was collected by Professor Compton for the first time in 1924, and since that date has spread rapidly, showing a marked tendency to colonise recently disturbed areas.

This species is much like *S. pterophorus*, a species common in the eastern parts of South Africa, and may be that species brought to the Cape Peninsula by human agency. However, it is extremely variable and gradually merges into *S. rigidus* L. on one hand and *S. rosmarinifolius* H.f. on the other, and the possibility of hybrid origin cannot be disregarded. Both putative parents occur in localities where the new *Senecio* is established.

A parallel is drawn with the case of *Spartina Townsendii* in England. It is suggested that this *Senecio* may be an allopolyphoid in which chromosome doubling has followed inter-specific hybridisation. A cytological investigation is being made to test this hypothesis.

B. F. J. Schonland,
Hon. General Secretary.

An Ordinary Meeting of the Society was held on Wednesday, May 17, 1933, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. A. W. Rogers, was in the Chair.

Business:—

The Minutes of the Ordinary Meeting held on April 19, 1933, were confirmed.

Dr. C. J. van der Horst, proposed by Professor T. A. Stephenson, seconded by the Hon. General Secretary, was nominated to Membership.

The Secretary announced that the following were candidates for election to Fellowship of the Society:—

L. J. Krige, Ph.D., proposed by A. W. Rogers (in 1932), S. H. Haughton, A. Young, and J. Smeath Thomas; C. van Riet Lowe, B.Sc., proposed by S. H. Haughton, A. Young, J. C. Beattie, D. F. Bleeck, W. Campbell, J. W. Gunn, K. H. Barnard; M. M. Rindl, D.Ing., proposed by E. Newbery, J. Smeath Thomas, A. Young, J. C. Beattie, R. H. Compton, and J. W. C. Gunn; B. J. Ryrie, M.B., Ch.B., proposed by J. W. C. Gunn, H. A. Reyburn, J. C. Beattie, and W. Campbell; J. M. Watt, M.B., Ch.B., proposed by J. W. C. Gunn, W. Campbell, M. R. Drennan, and A. Young.

The President announced that, at the invitation of the Council, Professor R. S. Adamson and Mr. J. H. Goodwin had accepted office, as Hon. Editor of Transactions and Hon. Librarian respectively, for the year 1933.

Communications:—

(*a*) "The Effects of Castration on the Urinary Creatinine of Female Rabbits," by I. Schrire and H. Zwarenstein.

As late as eight months after castration, no change is seen in the urinary creatinine excretion of female rabbits. About the ninth month past castration a definite rise is evidenced, and a month later there is a maintained rise of from 25 to 35 per cent. This rise is of the same order as that occurring in castrated male rabbits, but the interval between castration and the rise is from three to four times as long as that of the males.

(*b*) "The Effects of Injection of Ovarian Suspensions, Ovarian Extracts, and Testicular Extracts on the Urinary Creatinine of Normal and Castrated Female Rabbits," by I. Schrire and H. Zwarenstein.

Injections of ovarian suspensions and extracts cause a drop in the high creatinine excretion in castrated female rabbits to precastration levels. The drop is transient, and in a day or two after injection the creatinine excretion is once more at the normal castration level. Such injection into normal animals has a slight effect, and the drop in the creatinine excretion

is insignificant. Testicular extracts, prepared in the same way as the ovarian extracts, act similarly to the latter.

"South African Caddis-Flies (*Trichoptera*)," by K. H. Barnard.

This is a further report on the fauna of the mountain ranges of the S.W. Cape. A large number of new species have been discovered, and the larval and pupal stages of representatives of 19 out of 23 genera found in the Cape area have been correlated with the adults. The total number of species now known from South Africa is more than treble those previously known. The paper contains descriptions of all the known South African species.

"The Discovery of a Stone Age Manganese Mine at Chowa, North Rhodesia," by R. A. Dart.

B. F. J. Schonland,
Hon. General Secretary.

An Ordinary Meeting of the Society was held on Wednesday, June 21, 1933, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. A. W. Rogers, was in the Chair.

Business:—

The Minutes of the Ordinary Meeting held on May 17, 1933, were confirmed.

Dr. C. J. van der Horst, proposed by Professor T. A. Stephenson, seconded by the Hon. General Secretary, was elected to Membership.

Dr. J. Jackson, proposed by the Hon. Treasurer, seconded by the Hon. General Secretary, was nominated to Membership.

Communications:—

"Pigmentary Response in the Chameleon," by A. Zoond and Joyce Eyre.

1. In strong diffuse daylight chameleons show a response to background. They become dark on a black background, and pale on a white one.

2. Blind animals darken in the light. This response has been shown to depend upon the integrity of spinal reflex arcs.

3. The time relations of these responses have been determined.

4. The threshold for the retinal photoreceptors is lower than for the dermal ones.

5. In weak light the white background response is reversed. The animals become dark.

6. The following theory of nervous co-ordination is developed:—

(*a*) The melanophores are maintained in a state of tonic contraction by pigmentomotor fibres belonging to the autonomic system.

(*b*) Stimulation of the dermal photoreceptors by light inhibits the tonic innervation.

(*c*) Stimulation of the retinal photoreceptors by light from a light-absorbing background similarly inhibits the tonic innervation.

(*d*) Stimulation of the retinal photoreceptors by light from a light-scattering background causes an inhibition of the inhibition due to the simultaneous stimulation of the dermal photoreceptors.

"A Study in Biocoenosis," by A. J. HESSE.

The insect fauna dependent or biologically associated with the Western Province plant *Gnidia laxa* was studied during spring and summer. No less than seven orders of insects and members of the class *Arachnida* were found to be directly or indirectly dependent on this plant. The most important insects were found to be (1) a Curculionid-beetle, the larval stages of which excavate tunnels in the pith; (2) a Buprestid-beetle, the larval stages of which tunnel under the bark in the main roots; (3) a Braconid-wasp parasite of the Buprestid; (4) caterpillars of a Pyralid-moth, which feed in the leaves and are parasitised by the larvae of a new Tachinid-fly; (5) several kinds of beetles, bugs, and coccids, which feed on the plant; (6) new species of Thrips, which pass their entire life-history in empty tunnels in the stem; and (7) members of Carpenter-bees, which also use the empty tunnels for their larvae and pupae. Descriptions of the eggs, larvae, pupae, and adults are given in detail of most of these insects.

(*a*) "The Effects on the Urinary Creatinine of Normal and Castrated Rabbits of Injections of Anterior Lobe Pituitary Extracts," by I. SCHRIRE and H. ZWARENSTEIN.

Such injections transiently increase the elimination of creatine in normal male and female rabbits. In the castrated animals no change is apparent. There is evidence to show that the anterior lobe of the pituitary normally controls the creatinine excretion in the animal, and that the hypertrophy of the anterior lobe after castration is responsible for the increased excretion of creatinine in the gonadectomised animals.

(*b*) "The Metabolism of Injected Creatine by Normal and Castrated Male Rabbits," by I. SCHRIRE and H. ZWARENSTEIN.

Castrated male rabbits excrete the administered creatine to a greater extent and over a longer period than is the case in the normal animals. This is believed to be due to the excess of anterior lobe secretion of the pituitary of the castrated animal.

B. F. J. SCHONLAND,
Hon. General Secretary.

An Ordinary Meeting of the Society was held on Wednesday, July 19, 1933, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. A. W. ROGERS, was in the Chair.

Business:—

The Minutes of the Ordinary Meeting held on June 21, 1933, were confirmed.

Dr. J. JACKSON, M.A., D.Sc., F.R.A.S., was elected a Member of the Society.

The President announced that he had nominated Professor A. OGG as a Vice-President of the Society for 1933.

Communications:—

"Notes on *Rhopalota aphylla*, N. E. Br.," by R. S. ADAMSON.

This is a small succulent plant of subaquatic habit, found on the summits of the Cedarberg.

The plant produces only two connate leaves. Buds arise which form short-lived extensions on which flowers are borne.

Adventitious buds are produced. The base of the stem is slightly swollen and covered by cork. Successions of adventitious roots are formed, and the plant continues for several seasons.

The primary root of the seedling is cut off by a cork-forming meristem, which also adds to the internal tissue, and from which roots arise.

The plant is hygrophytic, and when dry loses water very rapidly and wilts, but readily recovers. Absorption is carried on both by the roots and by the aerial parts.

"Anatomical and Cytological Studies of *Clematis brachiata*, *Clematopsis stanleyi*, and Hybrids," by CLARICE G. CROCKER (communicated by Miss E. L. STEPHENS).

Clematis brachiata Thunb., a white-flowered climber, and *Clematopsis stanleyi* (Hook) Hut., a pink-flowered erect under-shrub, grow along the Witwatersrand. In certain localities where they occur in close proximity, numerous forms have appeared in which the characters of the two species are combined. Such forms, which are entirely absent where only one species is found, are considered to be natural hybrids. In spite of the very considerable difference in external appearance between the two species, and the wide range of combination of characters shown by the hybrids, anatomical differences throughout are shown to be slight, and no cytological differences were detected. The haploid number of chromosomes is eight, and meiosis is regular in both parents and in all the hybrids studied. The latter appear to be fertile and set seed freely.

B. F. J. SCHONLAND,
Hon. General Secretary.

An Ordinary Meeting of the Society was held on Wednesday, August 16, 1933, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The Vice-President, Dr. A. Ogg, was in the Chair.

Business:—

The Minutes of the Ordinary Meeting held on July 19, 1933, were confirmed.

Professor J. M. Hector, B.Sc., proposed by Professor J. S. van der Lingen, seconded by Professor L. Crawford, was nominated as a Member of the Society.

Communications:—

"The Breeding of Marine Animals," by Anne Stephenson and T. A. Stephenson.

"The Ascidians from the Cape Province," by W. Michaelsen (communicated by Professor T. A. Stephenson).

"The Growth-Changes of *Pteroplatea natalensis*," by J. L. B. Smith.

The Butterfly-ray, Pteroplataea, is frequently found in the Knysna estuary, and a graduated series of examples from the embryo up to the adult has been examined. The embryos are triangular in shape, with moderately developed pectoral fins. In the course of growth the pectoral fins become enormously developed until the transversely oval or lozenge shape of the adult is reached. The hitherto prevailing idea that large and small specimens represented different species is thus shown to be erroneous. Other presumed specific characters are also shown to vary according to age.

"Some Abnormal Specimens of the Panga," by K. H. Barnard.

Exhibition of abnormal specimens of the Panga (*Pagrus laniarius*), showing a gradual shortening of the snout until an extreme degree of "Pug-headedness" is reached. The "Pug-head" Panga is well known to the fisherman, and is not rare. Pug-headedness has been recorded in a number of different fishes, but not hitherto in the Panga.

(*a*) "Note on Relations between the Primary Minors of a 3-by-9 Array. (*b*) Note on an Overlooked Alternant," by Sir Thomas Muir.

B. F. J. Schonland,
Hon. General Secretary.

ANNUAL MEETING.

The Annual Meeting of the Society was held on Wednesday, September 20, 1933, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. A. W. ROGERS, was in the Chair.

Business:—

Dr. L. J. KRIGE, Mr. C. VAN RIET LOWE, Dr. M. RINDL, Professor B. J. RYRIE, and Professor J. M. WATT were elected as Fellows of the Society.

ORDINARY MEETING.

The Annual Meeting was followed by an Ordinary Meeting.

Business:—

The Minutes of the Ordinary Meeting held on August 16, 1933, were confirmed.

Professor J. M. HECTOR, B.Sc., was elected as a Member of the Society.

The President announced the death of the Rev. Father E. GOETZ, S.J., who joined the Society in 1904, and was elected a Fellow in 1910.

Communications:—

"Retinal Currents," by W. A. JOLLY.

(*a*) "Some Artefacts in Bushman Skulls suggesting Trepanning. (*b*) A Witch Doctor's Outfit from German South-West Africa," by M. R. DRENNAN.

"Climatic Changes and their Effect on Freshwater Molluscs," by F. G. CAWSTON.

The number of pond-snails in the Union has been lessened by the recent drought in the mountains and by anti-malarial measures at the coast.

The dearth of rushes and other large water-plants has discouraged the breeding of *Bulinus*, *Lymnaea natalensis*, and *Physopsis africana*. Climatic changes have resulted in a disappearance of many trees and shaded pools.

To-day one finds *Ancylidae* and *Lymnaea truncatula*, small species which can readily resist desiccation and are dependent on light. Though allied *Lymnaeae* may carry Fasciola infection, *Lymnaea truncatula* is the favourite host, and is found in the Union at very high altitudes, especially in mountain marshes.

Desiccation and frost will destroy many species of molluscs without destroying *Lymnaea truncatula*, which is therefore likely to become more prevalent in the Union.

"Further Notes on the Physiology of *Teloschistes flavicans*," by J. B. CUTHBERT.

B. F. J. SCHONLAND,
Hon. General Secretary.

An Ordinary Meeting of the Society was held on Wednesday, October 18, 1933, at 8.15 p.m., in the Board Room of the South African Association, Church Square, Cape Town.

The President, Dr. A. W. ROGERS, was in the Chair.

Business:—

The Minutes of the Annual and Ordinary Meetings held on September 20, 1933, were confirmed.

Professor D. M. BEACH, B.A., Ph.D., D.Litt., was nominated to membership.

A resolution, moved by Dr. L. CRAWFORD, seconded by Sir CARRUTHERS BEATTIE, authorising the Cape of Good Hope Savings Bank to accept the Hon. Treasurer's signature, was carried.

Professor RYRIE was admitted as a Fellow of the Society.

The Hon. Secretary announced that the following had been selected by the Council for recommendation to the Society as Officers and Members of Council for the year 1934:—

President, Dr. A. W. ROGERS; Hon. Treasurer, Dr. L. CRAWFORD; Hon. General Secretary, Mr. A. J. S. GOODWIN; Hon. Editor of Transactions, Professor R. S. ADAMSON; Hon. Librarian, Professor E. NEWBERY; Members of Council, Professor A. BROWN, Professor J. DALTON, Dr. L. GILL, Dr. S. H. HAUGHTON, Dr. J. HEWITT, Professor W. A. JOLLY, Professor A. OGG, Dr. E. P. PHILLIPS, Professor M. RINDL.

A resolution, moved by Dr. L. CRAWFORD, expressing good wishes to the retiring Secretary on his appointment as a Carnegie Travelling Fellow for 1934 and appreciation of his services to the Society, was adopted.

Communications:—

"The Declination at the University of Cape Town Magnetic Observatory: August 1932 to August 1933," by A. OGG and E. N. GRINDLEY.

This magnetic observatory, latitude 38° 57′ S., longitude 18° 28′ E., was established with the help of the International Commission for the Polar Year, the Department of Terrestrial Magnetism of the Carnegie Institution, the Carnegie Corporation, and the University of Cape Town.

A full programme of photographic recording of the declination, the horizontal intensity, and the vertical intensity by two sets of la Cour instruments has been maintained during the year.

The daily variation curves of declination for each month, which have been determined, show interesting changes from month to month. The curve for August 1933 is exactly similar to the curve for August 1932, with a secular variation of 4·2 minutes.

The monthly means are given in the following table:—

		Declination. Monthly mean. (*a*)	(*b*)	Time of max. westerly declination. G.M.T. h. m.	Mean daily range. (*a*)	(*b*)
1932.	Aug.	24° 43′·5	24° 43′·4 West.	10·00	8′·0	7′·6
	Sept.	43·5	43·4	9·38	10·3	10·9
	Oct.	42·6	42·6	8·40	11·3	11·4
	Nov.	42·0	41·9	6·45	10·2	9·8
	Dec.	41·1	40·9	6·40	11·3	10·3
1933.	Jan.	40·9	40·6	7·25	12·4	14·0
	Feb.	41·0	40·8	8·00	12·2	12·5
	Mar.	41·2	40·7	8·22	13·1	14·1
	April	41·2	41·1	8·44	9·9	10·1
	May	40·8	40·5	9·20	8·2	6·7
	June	39·8	39·5	9·20	6·6	5·7
	July	39·9	39·8	9·50	6·2	5·4
	Aug.	39·3	39·1	10·00	8·5	7·7

(*a*) All days of the month.
(*b*) Ten least disturbed days of the month.

"Continuous Recording of Cosmic Ray Intensities," by B. F. J. Schonland and B. Delatizky.

Instruments for obtaining continuous hourly measurements of the intensity of the cosmic radiation have been installed at the University of Cape Town. The records are obtained automatically. The station forms part of the international scheme for the study of variations in intensity of the rays with time organised by a European Committee, and is the only one in the Southern Hemisphere.

The station has been in continuous operation since February 1933, and will be carried on for another year. The accuracy of observation is 0·1 per cent. The reduction of the observations is being carried out in collaboration with the other stations in the scheme. The equipment, supplied by Dr. E. Steinke of Königsberg, was provided by the Research Grant Board through its Carnegie Fund, and by the University of Cape Town.

"The Phonetics of the Hottentot Language," by D. M. Beach.

The paper is based on the analysis of the pronunciation of over 100 Hottentot speakers, representative of all the Nama tribes, as well as Berg-

dama, Korana, and Griqua. The Nama dialect is taken as a standard and described in detail. In addition to the description of the vowels and consonants, there are chapters on the sound-attributes—length, stress, and pitch. It is shown that Hottentot is a tone-language of the Chinese type, and that there are six inherent tonemes of roots.

For purposes of comparative philology, the phonetics of the almost extinct Korana dialect is described, and is shown to be more like the standard Nama dialect than some writers have supposed.

A section on historical phonology shows that, contrary to the general view, Hottentot was not a monosyllabic language, but rather disyllabic; and that, contrary to Meinhof's opinion, Hottentot has not borrowed either clicks or tones from Bushman.

The paper concludes with a description of a proposed new practical orthography, based on the phonetic analysis.

"A Rapid Test for Pregnancy on *Xenopus laevis*," by H. A. SHAPIRO and H. ZWARENSTEIN.

The test is a modification of the Zondek-Ascheim test for pregnancy on rats and mice.

Early morning urine from women is precipitated with 96 per cent. alcohol. The precipitate is extracted with ether to remove oestrin and toxic substances, and the residue is then dissolved in distilled water.

Two to three c.c. of the aqueous extract is injected into each of four female South African Clawed Toads. Twelve to eighteen hours later a positive reaction is indicated by either (*a*) extrusion of macroscopic ova through the cloaca, or (*b*) post-mortem examination of the animal (in the absence of ovulation), when one ovum or more will be seen in either or both of the oviducts respectively. If (*a*) occurs in any one animal, post-mortem examination of the remaining animals is unnecessary.

The test is useful in differentiating pregnancy from conditions closely simulating it clinically.

Correct positive tests have been obtained as early as 20 days after the first missed menstrual period.

Of 35 cases investigated during September, 18 correct positives and 17 correct negatives were observed.

"Marine Fishes of Seven Genera New to South Africa," by J. L. B. SMITH.

"Notes on Geaster and Disceda, particularly as regards the Eastern Cape," by N. J. G. SMITH.

B. F. J. SCHONLAND,
Hon. General Secretary.